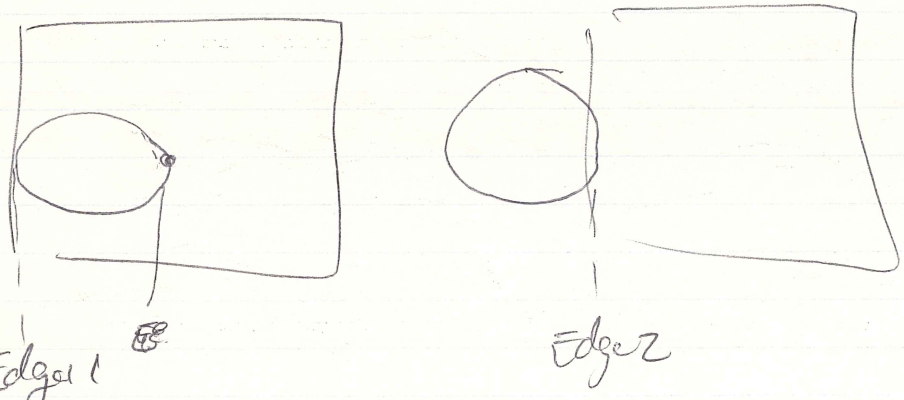
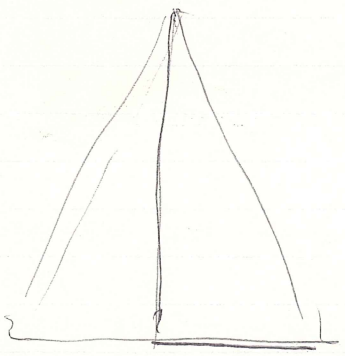
6 7/16" from B.B. To edge + 2.81" to detector

	(mm x 10)		R.V.
#93	~~1302 mm~~ ~~4150~~ 415.0	150.35	~~F.E.V.~~ 8.7
~~#94~~			
#94	388.15	56.5	8.1
112	370.2	35.4	8.2
5	375.3	50.0	7.9
217	375.5	50.2	7.9
49	370.0	70.0	7.3
22	400.0	30.2	9.0
215	385.0	45.2	8.3
79	390.0	60.3	8.0
50	410.2	65.5	8.4

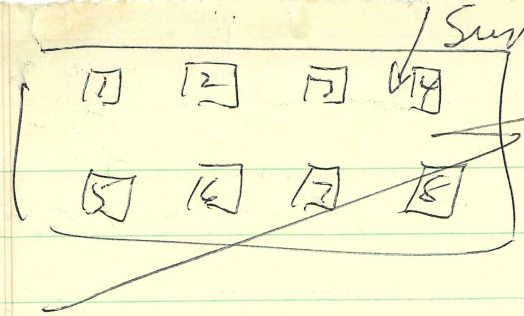
8.2
± 0.4



width = Edge 1 − Edge 2



April 1, 1987



wind direction
0 - 5 mph

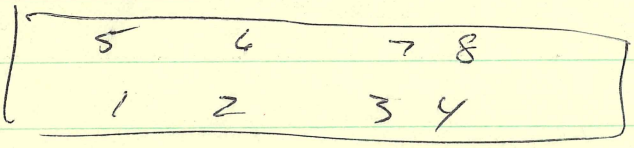
#	1	2	3	4	5	6	7	8
Inside in cases	72.3	72.1	71.8	71.9	72.1	71.4	71.4	71.3

On the Cart

Inside, out of case	72.8	72.4	72.2	72.1	72.7	72.2	72.0	72.2
start 2:17	85.3	85.0	84.1	84.8	85.9	85.5	85.2	85.6
2:22	85.4	87.0	86.1	84.1	83.1	85.3	85.2	85.9
2:28	86.2	88.2	91.0	87.6	88.0	89.2	91.3	88.9
2:41	89.4	91.9	93.0	93.5	90.1	94.2	95.7	92.7
2:46	90.4	96.3	97.1	93.9	95.5	99.4	94.2	92.8
2:53	94.0	93.8	94.2	92.6	89.2	90.6	96.1	92.3

Switch order on Cart

TA = 31 °C = 88 °F
31.5 = 88.7



	1	2	3	4	5	6	7	8
2:56	90.4	96.3	93.7	92.0	87.5	95.9	97.8	92.3
~~shutter~~ place on ground								
3:06	89.7	89.9	90.9	90.9	88.5	90.0	91.2	92.1
3:08	~~90.0~~	92.0	94.4	95.7	92.0	92.1	90.9	91.7
3:11	94.0	91.8	95.7	97.1	95.4	95.9	92.8	94.4
wind starts 3:14	89.3	90.6	90.3	91.0	89.5	91.4	93.3	91.7
3:15	88.2	87.6	89.9	89.4	88.5	89.2	89.6	91.1

aluminum foil gun = #9

Air = 30.7 = 87.3

	1	2	3	4	5	6	7	8	9 ★
3:24	89.2	90.0	90.7	90.1	88.4	90.3	90.5	90.1	83.1
3:28	94.2	88.7	94.8	94.1	99.6	97.0	95.3	93.7	87.4
3:31	92.7	91.2	95.0	93.7	91.0	92.8	93.9	93.4	86.2
3:34	92.7	92.2	94.2	96.9	96.3	93.1	95.3	92.6	85.5

Air = 30.7 = 87.3

3:37	94.2	91.8	94.0	94.4	92.2	92.8	92.9	93.9	85.0
3:39	93.1	89.8	94.1	97.9	95.2	96.0	97.9	96.1	86.5
3:42	87.1	86.7 (wind)	88.3	90.3	88.4	89.4	89.4	89.7	84.9

TA = 30.0 = 86.0

3:46	88.0	87.4	89.3	90.9	88.1	89.5	90.1	90.3	84.9
3:49	86.8	86.9	88.9	89.5	88.0	89.0	88.9	89.3	84.7
3:51	86.7	86.3	88.8	91.1	88.1	89.0	89.2	91.9	85.5
3:54	90.0	89.2	91.3	91.9	89.5	91.2	91.7	92.7	86.5

$T_A = 30.4 = 86.7$

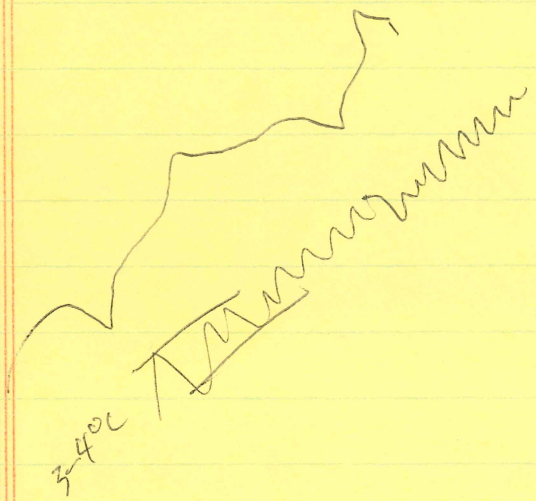
3:59	91.1	91.1	92.4	93.3	90.0	92.6	91.6	92.0	86.4

Test 2

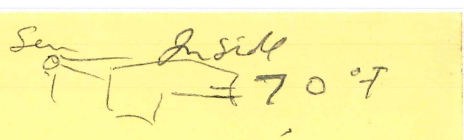
○ = 5 Volt Fan

Sunny, Breeze = 0-3 mph

(1)	2 (2)	(3)	4	(5)	(6)	Tf	Time
85.3	85.0	85.9	85.7	86.0	85	89.8	16:18
87.4	87.0	86.4	86.2	86.4	86	89.2	16:20
88.5	88.4	88.2	88.2	87.9	87	89.1	16:21
87.6	87.9	87.4	87.4	87.0	88	88.3	16:24
90.0	89.1	89.8	89.0	89.2	90	89.6	16:25
89.2	89.1	89.8	89.0	89.2	90	89.7	16:30
89.7	89.1	88.7	89.0	88.4	88	88.9	16:40
89.4	89.1	Breeze = 5-10 mph 89.5	89.0	89.1	89	88.9	16:45
90.6	89.1	90.6	89.0	90.7	91	88.7	17:06
90.2	89.1	91.2	89.0	91.4	92	89.1	17:14
90.7	89.1	90.6	89.0	91.1	91	88.9	17:17
91.4	89.1	90.1	89.0	90.7	92	89.2	17:24



○ = thermistor repositioned Outside cal 14:08 wind ≈ 10 mph



①	2	③	4	⑤	6	TA Time
83.4	84.4	83.6	84.1	83.9	83.7	86.0 14:13
86.6	87.5	86.4	86.3	86.3	86.1	86.9 14:14
85.9	86.1	86.3	86.2	86.2	85.9	87.3 14:15
87.7	86.2	87.6	87.5	87.7	87.2	87.8 14:18
88.3	86.2	87.8	88.1	88.5	87.9	87.8 14:20
88.9	87.6	88.5	88.4	88.9	88.3	88.3 14:22
89.3	88.8	88.7	87.9	88.5	87.7	88.5 14:25

Stand Changed

Sunny windy Sun 1 ~~88.7 14:34~~

90.3	90.6	91.0	91.0	90.7	90.5	88.7 14:34
91.1	91.5	91.2	91.7	91.5	90.4	88.5 14:37
89.4	89.4	89.2 Cloudy	90.0	89.5	89.0	87.6 14:39
89.3	89.1	89.1	90.0	—	89.0	86.0 14:41
88.9	89.0	89.2	89.5	89.2	89.4	86.0 14:44
91.5	89.0	88.7	88.6	88.9	88.6	86.0 14:46
89.6	89.2	89.2	90.3	89.7	88.9	86.9 14:52
92.1	90.4	90.7	Sunny color 92.0	91.3	91.4	88.8 15:24
91.6	90.1	91.8	91.6	91.5	90.9	88.7 15:25
93.5	93.4	93.1	93.9	93.7	93.6	89.6 15:27
92.3	90.1	91.5	windy 92.4	91.7	90.6	88.2 15:29

Rotate Stand
Sunny, some breeze

92.2	89.9	90.6	91.0	92.0	90.9	88.6 15:35
92.2	92.7	92.3	92.9	93.2	92.3	89.6 15:37

4/12/87
CBJ

→ ICR start TV

<28	*=<27	7/29 ≤30	≥28; <29
278		ok	no
469	B	+	−
278	*	469	339
325		100	273
31		36	391
363		284	312
358		261	310
264			255
291			269
196			381
331			300
282			206
414			247
245			168
283	*		165
260			318
346			246
288			364
448			292
387			444
244			327
455			361
391			256
314			316
			309
			437
			76
			266
			329

5

10

15

20

25

BAD 352, 279, 48, 411

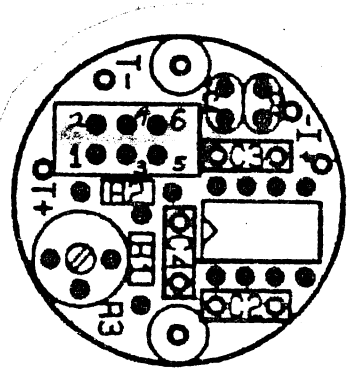
		Instruments cooling TB at 30	~~Tested~~ cooling ~~TB at 30~~	Warming TB at 30	Warming TB at 15
one	112 ✓				
	134 ✓	In		66 - In	
Sixteen	138 ✓	out		398 - In	
~~Eighteen~~ Sixteen	198 ✓	out		23 - out	
	21 ✓	✓ In		~~In~~	
	215 ✓	✓ In		129 - In	
	22 ✓	In		170 - BAD	
Seven	253 ✓	out		317 - BAD	
	28 ✓	✓ In			
Nine	404 ✓	out			
	450 ✓	In			
Eleven Twenty	482 ✓	✓ out			
	49 ✓	✓ In			
	50 ✓	~~In~~			
Twelve	79 ✓	out			
	93 ✓	✓ In			
	94 ✓	In			
	298	out			
	467	In			
	308	out			
	252	out			
	419	out			
	262	BAD			
	421	In			
	400	In			
	374	In			
	481	In			

IRT INTERFACE SPEC

Max Current Consumption : 1.3 mA into +5V line, out -5V line

Connector : dual-row header 2x3 .025 sq. pins, pin length = .318 in.

PIN #	FUNCTION	TEST CABLE
1	Thermistor +	Orange
2	Thermistor -	Blue
3	IRT Output	Green
4	Ground	White
5	- 5 V	Black
6	+ 5 V	Red



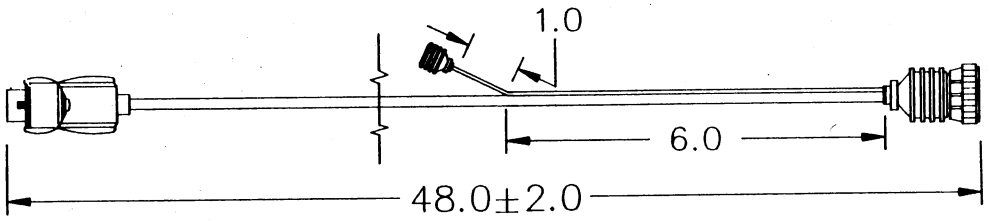
July 1, 1987

Oven Temp = 40° C

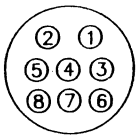
Ambient = ~~72.0 °F = 22°C~~ ~~23.0~~ 22.2 °C = 72.0
23.0 = 73.4

Time	5-V FAN	3-V FAN
14:25 3/4	77.2	79.8
14:26	76.9	79.7
14:27	75.8	79.1
14:28	75.0	78.7
14:29	74.7	77.6
14:30	74.8	77.5
14:31	75.5	76.7
14:32	73.7 In Spec	76.2
14:33	73.7	76.2
14:34	time - out	
14:35	73.8	75.7
14:36	73.2	76.3
14:37	73.9	75.6
14:38	73.6	75.3
14:39	72.4	74.3
14:40	72.9	75.5
14:41	73.1	75.1
14:42	73.1	75.8
14:43	72.9	75.6
14:44	72.8	74.6
14:45	72.6	74.7

DIMS. IN INCHES



PIN CONTACTS



WIRING SCHEDULE

SIGNAL DESCRIPTION	SIGNAL NAME	8 PIN CIRC. CONN.	COLOR	MALE DB25	CABLE PORT
CASE GROUND	RS_GND	5	BLUE	1	NC
DATA INTO COMPUTER	RS_RXD ←	3	BRN	2	NC
DATA FROM COMPUTER	RS_TXD →	6	GREEN	3	NC
SIGNAL GROUND	RS_GND	5	BLUE	7	NC
DTR OUT OF COMPUTER	RS_DTR →	7	ORN	8	NC
RING INTO COMPUTER	RS_RI ←	8		NC	
CARRIER INTO COMP.	RS_CD ←	1	YEL	20	NC
BAT. +	BAT. +	2	RED	NC	
BAT. GND.	BAT. GND.	4	BLK	NC	

PRINTER CABLE

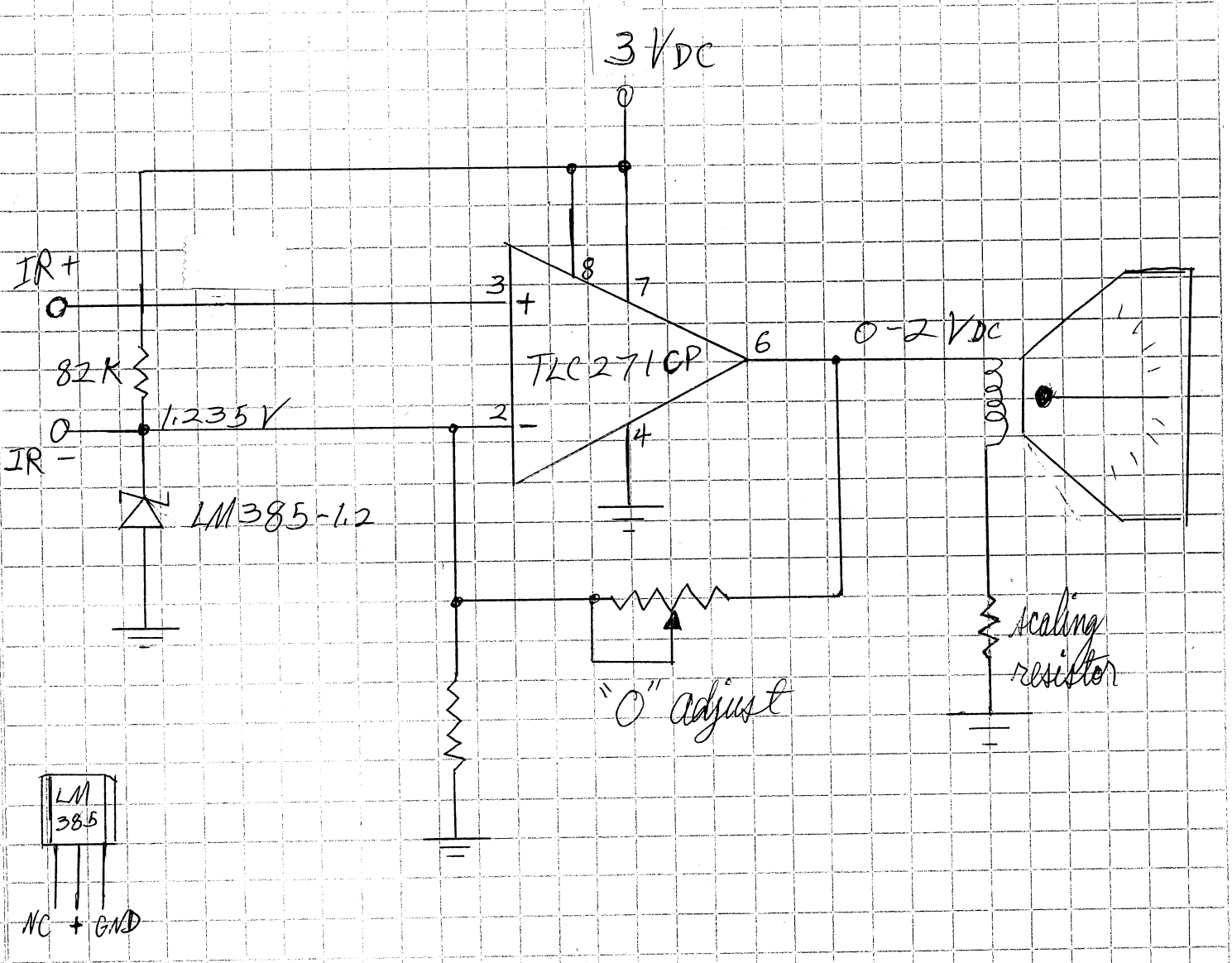
SUBJECT: SINGE-SUPPLY IRT Amp for Meter Movement

SHEET NO. ____ OF ____

FILE ____

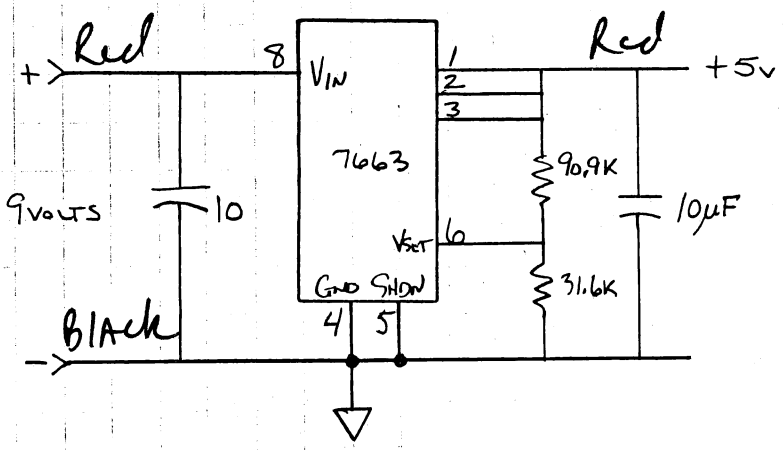
DATE 3/30/87

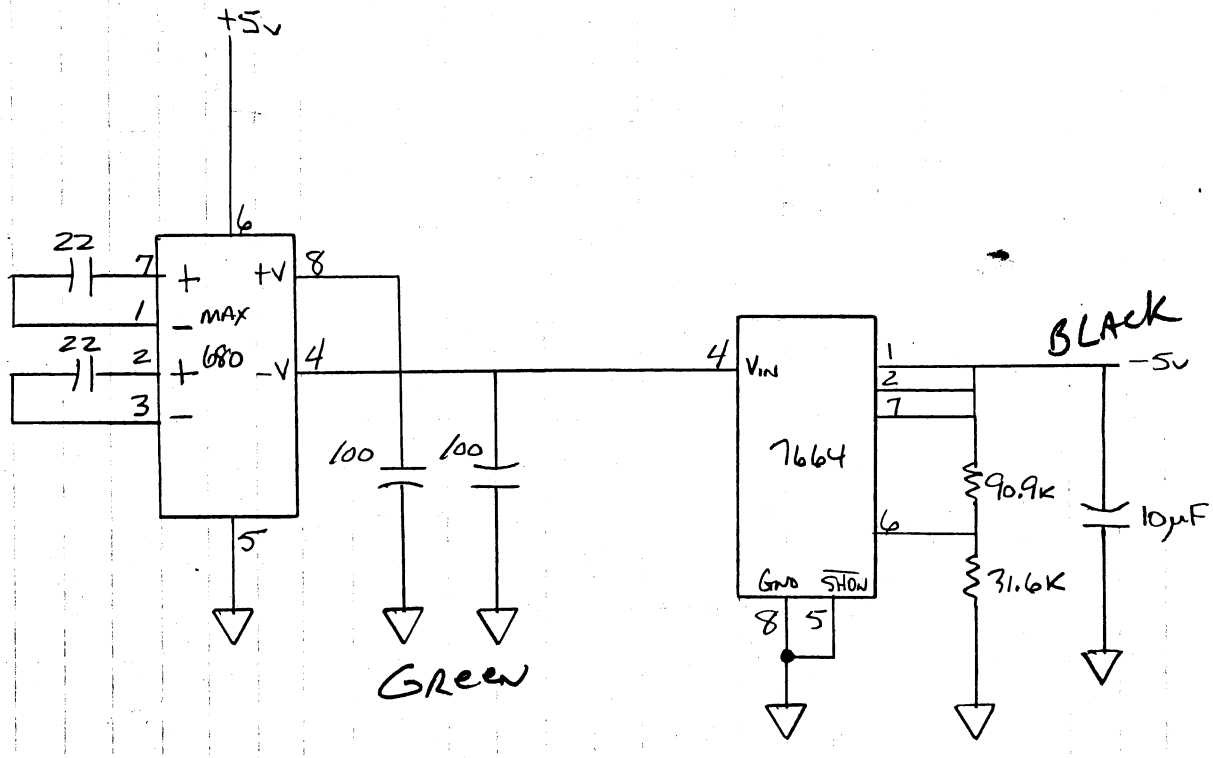
BY S. Gilbert



± 5 Volt Power Supply

4-7-87
Sme.





Hot Spatter Power Supply

SINGLE-SUPPLY IRT Amp for Motor Movement

3/30/97
A. Gillen

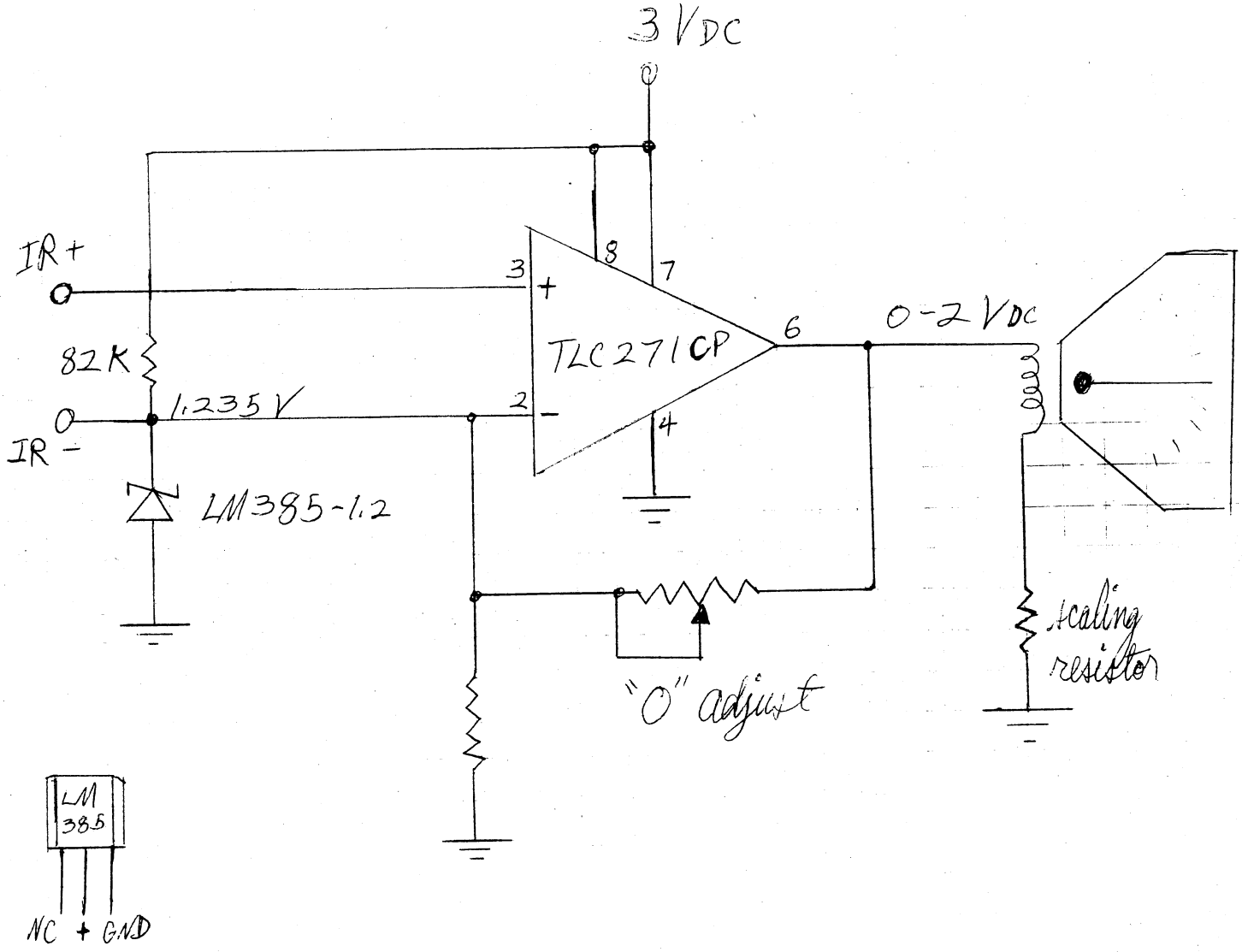
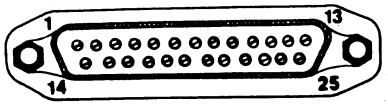


Figure 5-2:
Serial I/O Connector



bottom connector

PIN	DESCRIPTION
10	ANALOG CHANNEL 9
23	ANALOG CHANNEL 10
11	ANALOG COMMON (COMMON WITH ANALOG COMMON ON THE SENSOR CONNECTOR)
21	BATTERY CHARGE HIGH
19	BATTERY CHARGE LOW
2	(RS-232-C) TRANSMIT DATA (TD)
3	(RS-232-C) RECEIVE DATA (RD)
4	(RS-232-C) REQUEST TO SEND (RTS)
5	(RS-232-C) CLEAR TO SEND (CTS)
6	(RS-232-C) DATA SET READY (DSR)
7	(RS-232-C) SIGNAL GROUND (SIG GND)
20	(RS-232-C) DATA TERMINAL READY (DTR)
22	RING
16	RING EXCITATION
14	READY
12	LIGHT PEN GROUND
25	LIGHT PEN POWER
13	LIGHT PEN SIGNAL
1	NO CONNECTION
8	NO CONNECTION
9	NO CONNECTION
15	NO CONNECTION
17	NO CONNECTION
18	NO CONNECTION
24	NO CONNECTION

A

see also pages 7-3 through 7-7

Scheduler Cable		Polycorder
(1)	Ground	No Connection
(2)	Receive	Transmit
(3)	Transmit	Receive
~~(4)~~		
7	Ground	Ground
(6, 8)	~~DSR DCD~~ DTR	DSR
(20)	~~CABLE DSR~~ DCD	DTR

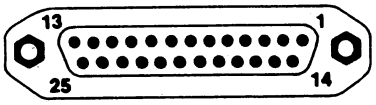
Scheduler	→	Polycorder (male 25 DB connector)
1, 7	→	7
2	→	2
3	→	3
6, 8	→	N. C.
20	→	25

THE CONNECTORS ON THE POLYCORDER

The connectors on the top of Polycorder are the input and output ports for digital, analog, and RS-232 signals. By wiring other devices to mating connectors and plugging them in, the Polycorder can "communicate" with these other units.

The Polycorder's connectors are 25 pin subminiature D" connectors. The Sensor Connector, the socket connector toward the front panel of the Polycorder, carries most of the analog and digital channels. The Serial Input/Output (I/O) connector, the pin connector, carries the RS-232 channels and two analog channels. The mating connectors that plug into the Polycorder's connectors are available from Omnidata or from your local computer or electronics store.

Figures 5-1 and 5-2 illustrate the connectors and describe the pins for the Sensor and Serial I/O connectors, respectively.



Top connector

Figure 5-1:
Sensor Connector
25 pin subminiature "D"

PIN	DESCRIPTION
14	ANALOG CHANNEL 1
16	ANALOG CHANNEL 2
1	ANALOG CHANNEL 3
3	ANALOG CHANNEL 4
15	ANALOG CHANNEL 5
17	ANALOG CHANNEL 6
2	ANALOG CHANNEL 7
4	ANALOG CHANNEL 8
18	ANALOG COMMON
5	5.000 VOLT EXCITATION
19	DIGITAL OUTPUT 1 (BINARY 1)
6	DIGITAL OUTPUT 2 (BINARY 2)
20	DIGITAL OUTPUT 3 (BINARY 4)
7	DIGITAL OUTPUT 4 (BINARY 8)
21	DIGITAL OUTPUT 5 (BINARY 16)
8	DIGITAL AND BRIDGE GROUND
22	DIGITAL INPUT 1
9	DIGITAL INPUT 2
23	DIGITAL INPUT 3
10	DIGITAL INPUT 4
24	DIGITAL INPUT 5
11	DIGITAL INPUT 6
25	DIGITAL INPUT 7
12	DIGITAL INPUT 8
13	DIGITAL INPUT 9

A

1. GENERAL COMMUNICATIONS DEVICE DESCRIPTION

Two types of RS232 communications equipment exist:

Type	Examples
DTE - Data Terminal Equipment	Printers, terminals
DCE - Data Computer Equipment	Computers

The difference between the two types of communication equipment is the interpretation of the various signals. For DTE equipment the following interpretation applies:

Signal Name	Usage	25 Pin D-Shell Connector Pin
Transmit	Output	3
Recive	Input	2
DCD (Carrier Detect)	Input	8
DTR (Data Terminal Ready)	Output	20

For DCE equipment the following interpretation applies:

Signal Name	Usage	25 Pin D-Shell Connector Pin
Transmit	Output	2
Receive	Input	3
DCD (Carrier Detect)	Input	20
DTR (Data Terminal Ready)	Output	8

The Scheduler(tm) Plant Stress Monitor port and the Epson FX-85 printer port are wired to be DTE (Data Terminal Equipment) devices.

2. SCHEDULER(tm) Connections to Printers

To be compatible with the Plant Stress Monitor, the DCD signal must always be used to indicate if the connected device is BUSY or READY. Likewise, the Plant Stress Monitor uses its DTR signal to indicate when it is BUSY or READY to accept data.

A "READY" is indicated by a SPACE (+3 to +25 Volts on the cable).
A "BUSY" is indicated by a MARK (-3 to -25 Volts on the cable).

If the device being connected does not adhere to the above definition and is still to be used with the Plant Stress Monitor, then a cable must be made which will cause the Plant Stress Monitor to think the device is compatible (i.e. the above defined voltages must be "forced" onto the defined pins on the cable).

2.1 SCHEDULER(tm) to a SERIAL PRINTER

Note if a DTE device is to connect to a DCE device then the connecting cable is a straight through cable -- i.e. all pins on one side of the cable connect to their corresponding pins on the other side of the cable.

If a DTE device is connected to another DTE device (as is the case of the Plant Stress Monitor and a printer) or a DCE device is connected to a DCE device then pins 2 and 3 and 1 and 4 must be crossed -- the cable must be configured as follows:

Pin 2 connects to pin 3
Pin 3 connects to pin 2
Pin 8 connects to pin 20
Pin 20 connects to pin 8

The above is the configuration of the Plant Stress Monitor's printer cable -- it is wired to be a NULL MODEM cable.

2.2 SCHEDULER(tm) to a PARALLEL PRINTER

If the printer to be used has a parallel interface, the following two options are recommended for transferring data to the printer:

A) Transfer the information to the PC as outlined below and then print the data file using the PRINT command on the PC.
B) Purchase a serial to parallel converter data converter:

Harmonizer
Applied Creative Technologies
Dallas, Texas

TO BE ADDED

3. SCHEDULER(tm) Connections to a PC

If the Plant Stress Monitor is to be connected to a PC then a special cable must be built. This cable is a straight through cable (no wires crossed, all pins connected to their corresponding pins on the other side) with pins 6 and 8 jumpered (shorted) together on the PC side.

4. File Transfer From the SCHEDULER(tm) to a PC

To transfer information from the SCHEDULER(tm) to a PC, connect the appropriate cable from the SCHEDULER(tm) to the PC. Then execute the following commands on the PC:

```
MODE COM1:12,N,8,2
COPY COM1 <filename>
```

On the SCHEDULER(tm) execute the following:

1) power-up the unit
2) press the PRINT key
3) using the ENTER, UP-ARROW, DOWN-ARROW keys, set the following parameters:

BAUD RATE	1200
CHAR. SIZE	8
STOP BITS	2
PARITY	NONE
XON/XOFF	DISABLED
SUN_LOW	either DISABLED or ENABLED

4) If the historical data is desired press the CALC key, or if the current day data is desired press the ENTER key.
5) Press the PRINT key to start the data transfer to the PC.

At this point any SCHEDULER data that would have printed to the printer will now print into the file on the PC. The file format is the same as the format that prints when connected to the printer.

RECOMMENDATIONS FOR BRONSON GARDNER'S COMPUTER

Steven A. Zilber 3/30/87

1. If IBM XT, add Orchid Technologies Tiny Turbo 286 card. Comes with 80287 coprocessor; try to get 10 MHz version. This card will make XT almost as fast as an 8 MHz AT, 4 times as fast as an XT. $450.

2. Add at least 1 Meg of RAM; use AST SIXPAK Premium Plus if XT, AST Advantage if AT. This will allow Windows, RAMdisks, etc. You also get I/O ports and clock/calendar. ~$350.

3. Get a copy of POLYBOOST to speed up computer; implement 512K hard-disk cache, 64K print buffer. $70.

4. Get trackball for cursor control. ~$200.

5. If doing heavy-duty graphics, get clone of IBM PGA card, ~$700, and comparable mono or color monitor, ~$1000.

#84

Δ Static = 100 sec
T_B = 80.6 F = 27.0 C

Start Counts	T_D	Static	End Counts	T_D	Static
~~229~~	~~136.7~~				
-2265	136.4	53.0	-2090	131.5	55.2
-2045	130.9	56.5	-1873	126.4	58.9
-1803	~~125.5~~ 125.0	60.3	-1664	121.3	62.0
-1634	120.7	62.6	-1513	117.3	63.8
-1484	116.5	64.1	-1350	113.5	66.2
-1341	113.0	66.0	-1215	110.3	68.0
-1206	109.8	67.8	-1106	107.4	69.1
-1080	106.6	69.3	-980	104.4	70.7
-943	103.3	70.9	-870	101.4	71.6
~~-1128~~	~~100.3~~				
-792	99.3	72.3	-724	97.8	73.1
-673	96.6	73.7	-617	95.3	74.4
-591	95.0	75.0	-558	93.9	75.0
-511	92.9	75.6	-477	92.0	75.9
-468	91.8	76.0	-420	90.8	76.7
-406	90.5	76.8	-385	89.8	76.8
~~-371~~	~~89.4~~				

#141 Start

$T_B = 80.6$
Ambient = 27.2

End

Counts	T_D	Static
1110	50.8	85.3
~~1121~~	~~65.4~~	~~84.1~~
971	54.4	84.7
859	57.6	84.5
759	60.5	84.3
676	62.7	84.0
598	64.7	83.5
530	66.6	83.3
457	68.6	83.1
397	70.1	82.6
330	72.1	82.5
261	73.9	82.1

Counts	T_D	Static
1002	53.6	84.9
887	56.9	84.7
782	59.7	84.3
681	62.4	83.8
605	64.5	83.1
543	66.2	83.4
478	68.0	83.1
408	69.8	82.7
355	71.2	82.4
290	73.0	82.2
227	74.6	81.8

#141 Start

ΔTime = 100 seconds

$T_B = 80.6$

End

Counts	T_O	Static
-2036	137.5	64.2
-1800	131.1	67.2
-1618	126.2	69.3
-1458	121.7	70.8
-1304	117.3	72.1
-1173	113.1	72.7
~~-1037~~	~~109.8~~	~~74.0~~
-936	106.5	74.6
-851	104.0	75.1
-745	101.3	76.1
-680	99.2	76.2
-612	97.4	76.8
-554	95.8	77.1
-469	93.6	77.8
-427	92.4	78.1

Counts	T_O	Static
-1835	132.6	67.4
-1629	126.8	69.5
-1479	122.3	70.6
-1346	118.2	71.4
-1203	114.2	72.7
-1072	110.4	73.6
-864	104.4	75.0
-787	102.1	75.4
-693	99.7	76.3
-625	97.7	76.6
-564	96.1	77.1
-510	94.6	77.5
-441	92.6	77.8
-399	91.6	78.2

Start #5

Counts	TO	Static
~~1169~~	~~55~~	
1143	52.4	87.9
1015	55.8	87.4
859	59.6	86.5
743	62.5	85.8
623	65.4	85.0
562	67.3	85.0
~~548~~ 469	69.2	84.0
394	71.2	83.7
342	72.6	83.4
302	73.8	83.4

End

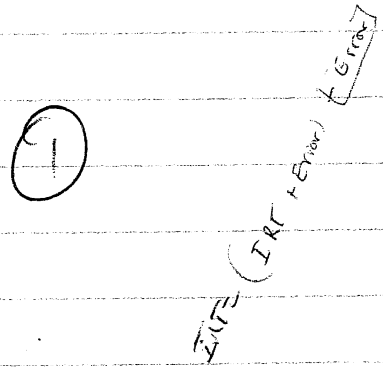
Counts	TO	Static
1034	55.1	87.3
917	58.2	86.9
779	61.7	86.1
667	64.3	85.3
566	66.9	84.8
498	68.6	84.3
434	70.4	84.1
353	72.2	83.4
303	73.5	83.1
257	74.6	82.7

#5 Start 12:20 End 12:55

Counts	T_D	Static	Counts	T_D	Static
-2152	137.3	59.0	-1974	132.3	61.1
-1955 ~~1367~~	~~135.7~~ 131.6	61.2	-1770	127.0	63.9
-1739	126.0	64.1	-1583	121.9	66.0
-1554	121.1	66.3	-1423	117.4	67.8
-1370 ~~1463~~	116.3	68.5	-1247	113.1	69.8
~~-869~~	~~112.5~~				
-1176	111.1	70.4	-1075	108.5	71.5
-1055	108.1	71.8	-988	105.7	71.8
-953	105.2	72.5	-873	103.0	73.2
-854	102.6	73.5	-785	100.8	74.1
-774	100.3	74.0	-704	98.7	74.8
-701	98.4	74.6	-641	96.8	75.1
-633	96.6	75.2	-577	95.3	75.8
-567	95.0	75.9	-520	93.9	76.4
-513	93.6	76.3	-464	92.5	76.9
-456	92.3	77.0	-420	91.4	77.3
-396	~~90.0~~ 90.8	77.5	-368	90.0	77.6
-350	89.6	77.8	-322	88.9	78.1

START #84 $T_B = 80.6$

Counts	T_D	Static	Counts	T_0	Static
1328	50.4	91.1	1193	53.2	90.0
1167	53.9	90.0	1056	56.4	89.2
1024	57.3	89.1	919	59.5	88.2
895	60.2	88.2	806	62.2	87.5
794	62.5	87.4	726	64.2	87.0
685	65.0	86.5	622	66.5	86.1
603	66.8	85.8	544	68.1	85.3
534	68.5	85.4	475	69.7	84.7
437	70.6	84.4	392	71.5	83.9
381	71.9	83.9	345	72.7	83.6
337	73.0	83.7	299	73.7	83.2
270	74.4	82.9	242	74.9	82.5



#241

Start Counts	T_D	STATIC	End Counts	T_D	STATIC
~~1294~~	~~49.9~~	~~89.8~~	~~1163~~	~~51.0~~	~~87.1~~
1136	52.1	87.4	1027	54.9	86.9
1003	55.5	86.8	901	57.9	86.1
871	58.7	86.0	795	60.8	85.7
772	61.2	85.4	704	63.1	85.2
679	63.7	85.1	610	65.4	84.6
603	65.7	84.7	534	67.2	84.1
517	67.9	84.2	462	69.2	83.8
436	69.8	83.6	388	70.9	83.2
384	71.2	83.4	347	72.2	83.2
333	72.4	82.9	298	73.2	82.5

#241 Start 11:24

Counts	T_D	Static Temp	TB	Counts	T_D	Static Temp
~~-2291~~	~~139.5~~					
				-1931		
-2141	135.9	57.9		~~-1931~~	130.6	61.1
-1882	129.2	61.6		-1718	124.8	63.6
-1665	123.8	64.6		-1519	119.8	66.3
-1502	119.3	66.3		-1373	115.8	67.8
-1347	115.2	68.2		-1224	112.1	69.6
-1205	111.5	69.7		-1099	108.8	70.9
-1085	108.3	70.9		-987	105.9	72.0
-966	105.2	72.1		-881	103.0	72.9
-873	102.6	72.8		-793	100.6	73.6
-785	100.3	73.6		-707	98.5	74.5
-694	98.0	74.4		-634	96.5	75.0
-604	95.6	75.2		-552	94.4	75.8
-528	93.8	76.0		-487	92.7	76.3
-468	92.3	76.5		-431	91.3	76.8
-424	91.1	76.8		-390	90.2	77.1
~~-383~~	~~90.0~~	~~77.1~~		~~-356~~	~~89.0~~	
-337	88.8	77.5		-304	88.1	77.9
-299	87.9	77.8		-272	87.3	78.1
-265	87.1	78.2		-242	86.6	78.5
-227	86.2	78.5		-209	85.7	

End 12:18

Chamber Temperature = 119.2°F

17 March

IRT Dynamic Data

Ambient = 20.6

Δ Seconds = 30 T_B = 30.0 °C

Sensor	Time	
#167	8:36 — not working	
~~#94~~	~~Tested Aborted~~	
#139	O.K.	Ambient = 20.6
#93	O.K.	Ambient = 20.8 → 21.4
#141	O.K.	= 21.5 → ~~23~~. 23.0
#50	O.K.	
#112	O.K.	23.6 → 24.4
#215	O.K	24.3 →
#217	O.K.	25.7
#84	OK	25.9
#170	OK	25.8
#24~~9~~	OK	26.1
#5	OK	26.6
#~~49~~22	OK	27.4
#18	OK	27.3
#94	OK	—
#79	OK	24.4
#49	OK	

Login file

Kermit:==$ D8:[Cooped.Kermit]Kermit.Exe

Maximum errors in the alfalfa index for a 5% error in RH and a 0.6 °C (1.1 °F) error in $T_C - T_A$.

RH %	Temp (°F) 15 59	20 68	25 77	30 86	35 95	40 104	45 113
0	1.4	1.3	1.2	0.9	0.7	0.4	0.3
10	1.6	1.4	1.3	1.1	0.9	0.4	0.4
20	1.7	1.5	1.4	1.2	1.0	0.8	0.4
30	1.8	1.6	1.5	1.4	1.2	0.9	0.4
40	2.0	1.9	1.7	1.5	1.4	1.2	0.9
50	1.5	2.0	1.9	1.7	1.7	1.5	1.3
60	1.5	1.5	2.1	2.0	2.0	1.9	1.7
70	1.5	1.5	1.5	2.4	2.4	2.5	2.2
80	1.5	1.5	1.5	1.5	3.1	3.2	3.3
90	1.5	1.5	1.5	1.5	1.5	1.5	1.5
100	1.5	1.5	1.5	1.5	1.5	1.5	1.5

13

95

DEXTER SENSOR SORTING 3/30/87

PURPOSE: The purpose of this procedure is to develop a technique of quantifying the DC output of Standard Oil detectors. Detectors will them be screened for units in a desireable output range.

MATERIALS: A 50 °C flat black body (BB) was constructed of 28 gauge nichrome wire sandwiched between 5 mil mylar insulators and 3/16 inch thick by 7 inches square aluminum plates. Air spaces within the structure were epoxy filled. An iron-constantan thermocouple was epoxy embedded into the center of the forward facing plate which also was painted flat black. The rear of the BB was covered by one inch styrofoam insulation. A cardboard pyramid, 5 cm high with 1.5 inch square window at the apex was attached to the BB; the window was covered by .1 mil polyethylene. A variable power supply was used to heat the BB to 50 +/- 0.1 °C (about 25 VDC). Thermocouple output (2.585 mv nominal) was monitored by a DMM referenced to a 0 °C water-ice mixture maintained in a Dewar flask. The temperature measured at 16 points distrubuted across the face of the BB did not vary more than 1 °F from the value at the plate center (fig. 1).

In order to maintain the detectors at relatively constant reference temperature, they were fitted with heat sinks made of zinc plated steel nuts. The detector holder was a 6 inch steel tube with teflon Augat socket at one end, and cable connecting it to a DMM at the other. A handle of styrofoam insulation was attached to the cable end to reduce heat absorption while manipulating the holder. Ambient temperature was monitored with an EXERGEN radiometer placed on the face of the steel equilibration plate and recorded in °F (fig. 1).

METHOD: Detectors were placed in the holder and heat sink and placed face down aginst a 5 inch square steel plate on the bench top. Equilibration was allowed until detector output was changing at a rate less than .01 mv/15 seconds. Most detectors equilibrated within 30 to 60 seconds. The detector with heat sink was then rapidly placed against the vertically oriented BB window. Since the heat sink was taller than the detector by about 1 mm, the front of the detector did not touch the window material. Detector output usually increased initially, reached a peak which was maintained for about 10 seconds and then slowly decreased at about .01 mv/7 seconds. The recorded peak was usually less than .05 mv higher than the initial output (FIG. 2).

RESULTS: Correlations between ambient temperature and detector output were made on one unit (#4) to allow comparisons between data obtained at different ambient temperatures or between laboratories (fig. 3). Output fell off rapidly from 6.17 mv at 68 °F to 5.74 mv at 75 °F or about .06 mv/°F.

Repeated measurements were made on several detectors to ascertain the reproducibility of the technique (Table I, below).

TABLE I
Comparison of Std Oil & DRC data on selected detectors

Temp °F Det#	STD OIL 78.8	DRC 69	DRC 73	DRC 75
4	3.52	6.13	5.88	5.74
83	3.52	5.98	5.74	5.59
125	3.54	6.23	5.97	5.82
23	3.80	6.58	6.23	6.10
69	3.79	6.42	6.20	6.05
118	3.80	6.45	6.22	6.07
60	4.08	6.52	6.23	6.09
92	4.09	6.93	6.60	6.49
100	4.05	6.64	6.35	6.23

Comparisons between data generated to Standard Oil and Dexter Research are shown in Table II (below). Even compensating for temperature differences, the absolute rank order is not the same between the two laboratories. However, the data does correlate in a general sense in that the detectors with highest and lowest output were identified by both groups.

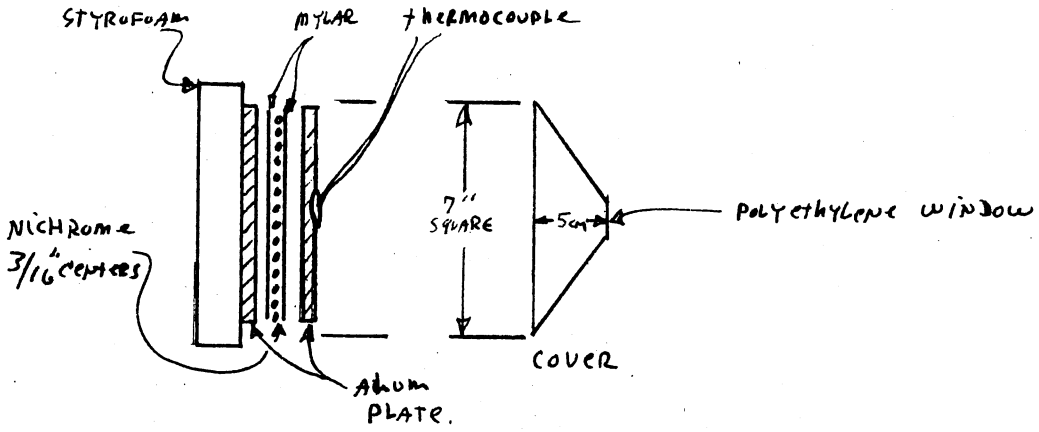
TABLE II
Rank order of detectors from high to low output

Temp °F	Std Oil 78.8 Det#	DRC 66	DRC 71
	88 (3.51 mv)	20 (6.51 mv)	20 (6.25 mv)
	47	97	97
	40	47	47
	114	40	40
	20	88	88
	97	S-4	S-4
	S-4	121*	114*
	80	114*	121*
	121*	128*	80*
	119*	80*	128*
	128* (3.32 mv)	119 (5.83 mv)	119 (5.54 mv)

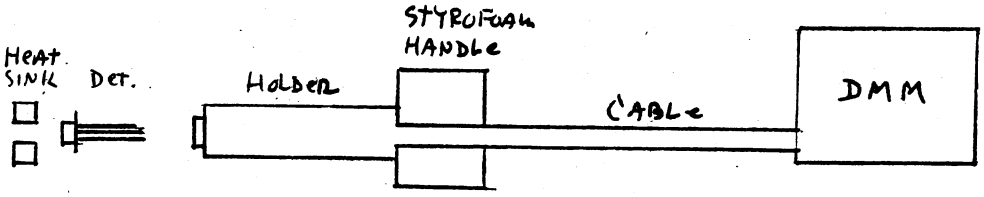
* detectors with approx. same output within labs.

Selection of detectors with acceptable sensitivity was made using a lower cutoff between values represented by detectors #4 and #13. The upper cutoff was set at about 15% higher than the lower (fig.3). Using these criteria, some of the detectors returned to DRC as being too low in sensitivity were well within the acceptable range. However, all of the detectors returned as too high were well out of the acceptable range. The second batch of detectors were screened on the basis of the above criteria and shipped to Ray Kline on 3/23/87.

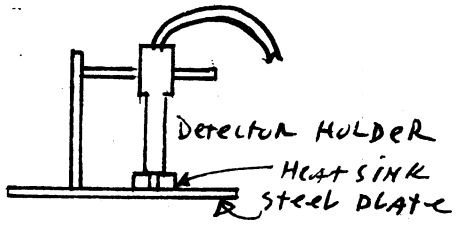
FIG. 1 APPARATUS FOR STANDARD OIL DETECTOR MEASUREMENTS



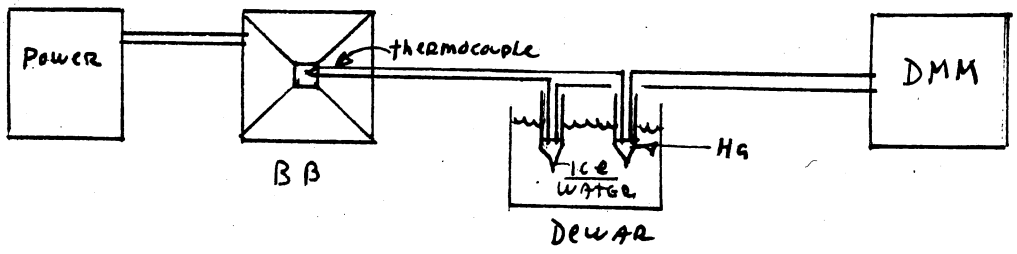
A. 50°C FLATE PLATE BB.



B. Detector Holder + Heat SINK



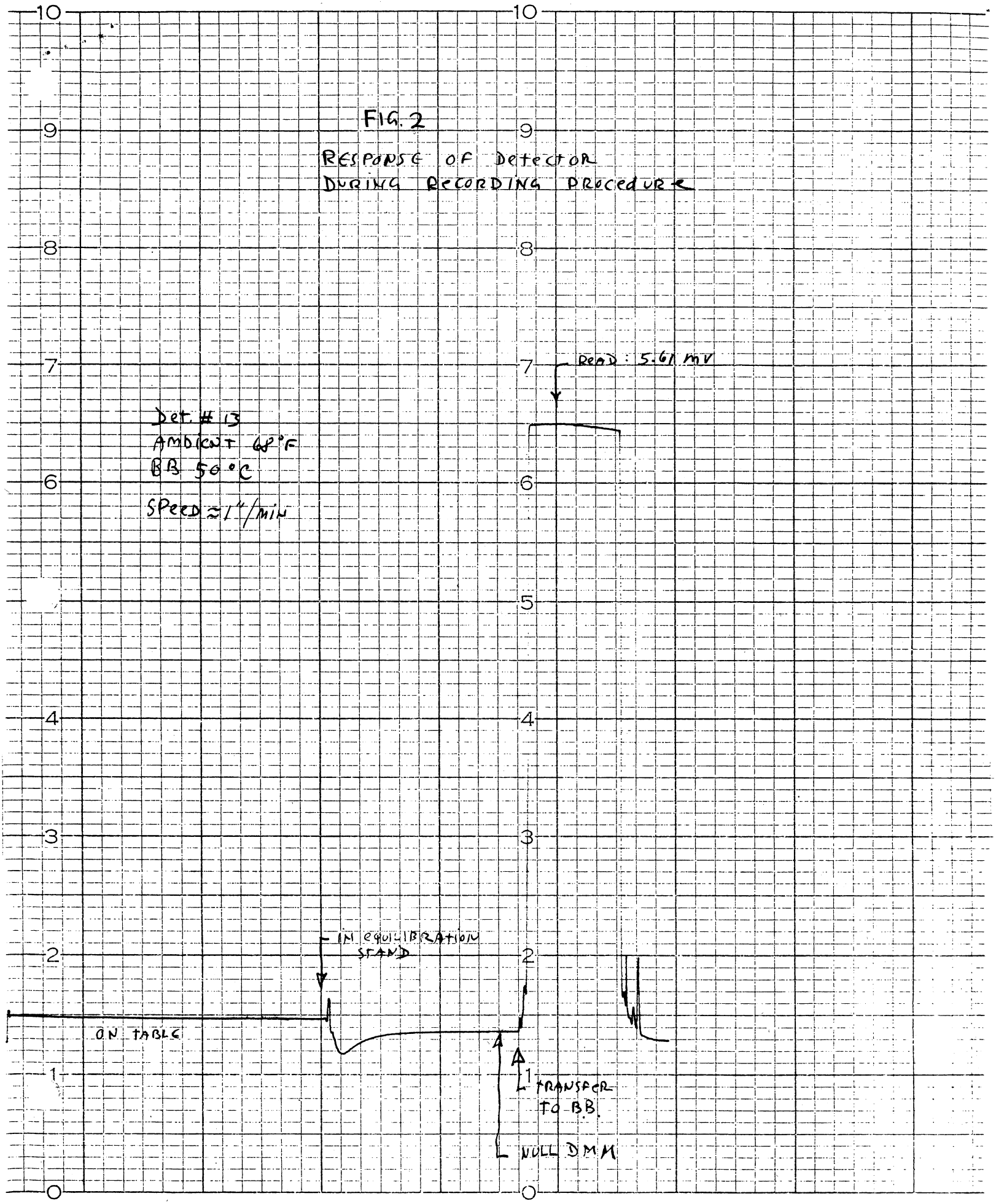
C. EQUILIBRATION STAND



D. BB TEMPERATURE CONTROL

FIG. 2

RESPONSE OF DETECTOR
DURING RECORDING PROCEDURE



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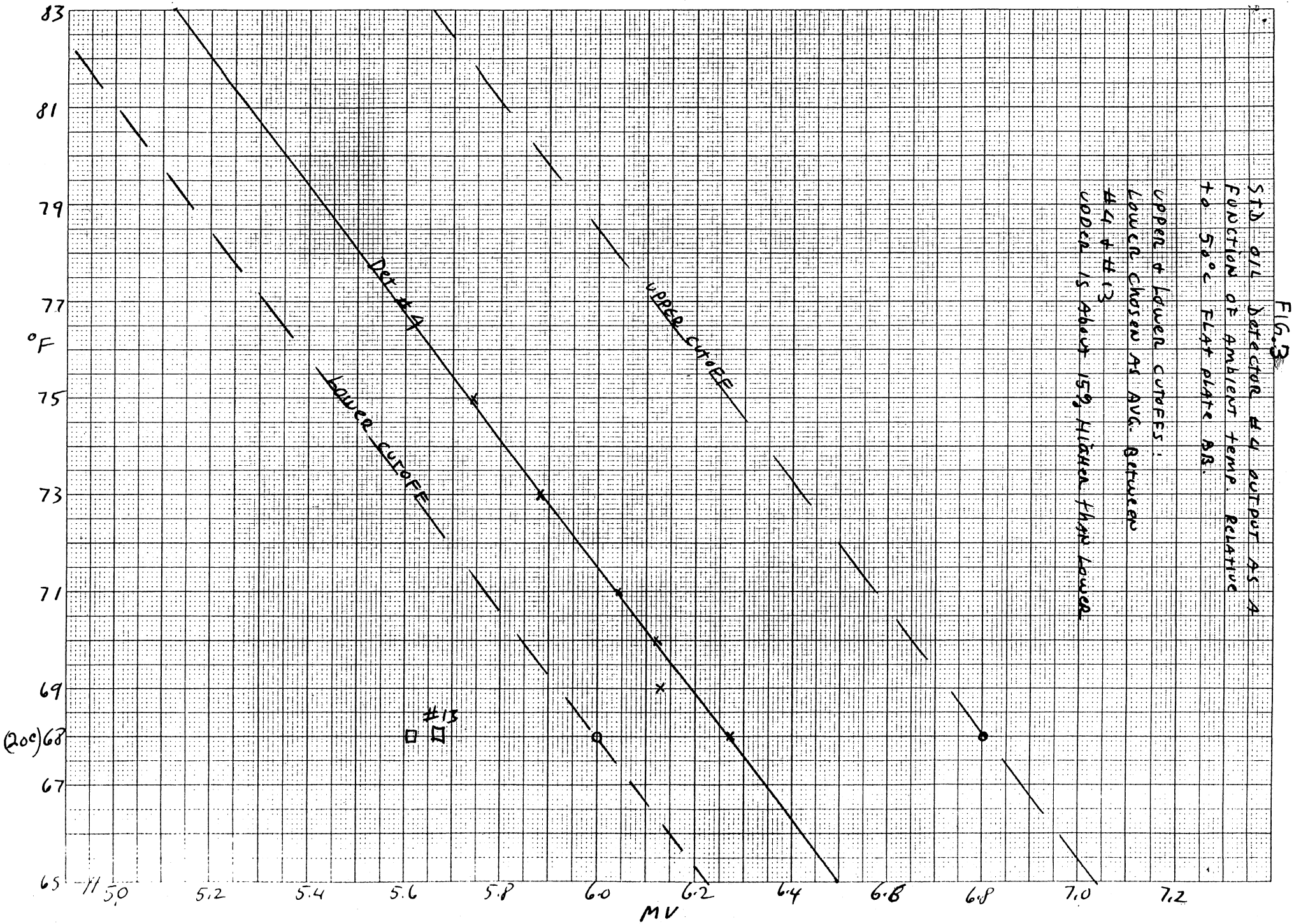

FIG. 3

STD. O/L Detector #4 output as a function of ambient temp. Relative to 50°C flat plate BB.

Upper & lower cutoffs: Lower chosen as avg. between #4 & #13.

Noise is about 15% higher than lower

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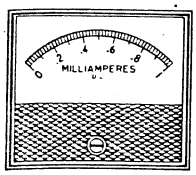
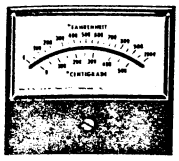
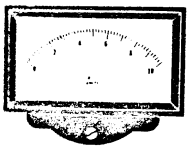


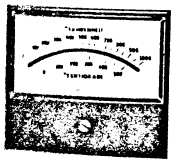
G Series
- Sizes:
  1½", 2½", 3½", 4½", and 5½"
- Case:
  Thermoplastic Front and Back—Four-Stud Mounting.
- Option:
  Shallow Barrel available on 1½", 2½", 3½" and 4½" units.
- Half Bezel and Illumination available on 2½", 3½", 4½" and 5½" units as accessories.



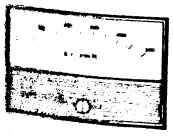
GL Series
- Sizes:
  2½", 3½", 4½", 5½" and 8"
- Case:
  Flat Black, Thermoset-Plastic Case—Glass Window—Contains Contoured Base with Sealed Meter Movement Permitting Use of Lower Part of Front for Mounting Controls and Switches—as well as Four-Stud Mounting.
- Exceptions:
  220GL and 820GL—Four-Stud Mounting Only
- Options:
  320GL—Three-Stud Mounting Also Available
  320GL, 420GL & 520GL—Four-Stud Mounting
  820GL—Optional Thermoset-Plastic Accessory Case with Handle Available.
  (See Accessories Section).



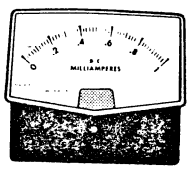
GLB Series
- Sizes:
  3½", 4½", 5½"
- Case:
  Minimum Panel Space Required for Series—Thermosetting Plastic Case—Glass Window—Integral Bezel, which Permits Behind Panel Mounting.



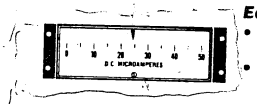
WS Series
- Mounting:
  Choice™ of Back-Of-Panel for Window Mount, or Front-Of-Panel.
- Sizes:
  Available from 2½" to 4½"
- Options:
  Custom Dials, Special Pointers, Mirror Scales and Special Meter Characteristics (Contact Factory).
- Versatility:
  Interchangeable with API/LFE 204 and 304, Most Beede QAS and QAW Series, Modutec W and S Series and the Weston 8500 Series



R Series
- Sizes:
  3½" and 4½"
- Case:
  Thermoplastic Front and Thermoset-Plastic Back with Flat Arc Scale.



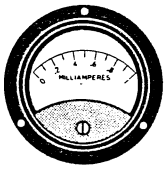
M Series
- Size:
  8½"
- Case:
  Thermoplastic, Front and Back
- Option:
  Thermoset-Plastic Accessory Case with Handle Allowing Use in Special Test Equipment.
  (See Accessories Section)



Edgewise Series
- Sizes:
  ½", 1½", 2½", 3½", and 4½"
- Case:
  Thermoplastic Front, All Models—Thermoset Plastic Back. (Except Model 0.5-E, with Steel Back)
- Rugged Model 320EG:
  Sealed Glass Window, Thermoset Plastic Back, Constructed to Withstand Tough Environmental and High-Vibration Industrial Applications.
- Versatile:
  Edgewise Meters Can be Supplied with One of Eight Possible Orientations:
  Horizontal Barrel Down—Zero Left or Right
  Horizontal Barrel Up—Zero Left or Right
  Vertical Barrel Right—Zero Bottom or Top
  Vertical Barrel Left—Zero Bottom or Top
  Dual Movement—320ED Series

Phenolic Series
- Case:
  All Models Below Feature Thermoset Plastic Case with Glass Windows.
- Option:
  Illumination Available for Certain Models
  (Contact Factory).
- Specifics:
  Models 227T and 327T—2½" and 3½"—
  Four-Stud Mounting.
  Models 221T and 321T—2½" and 3½"—Three-Stud Mounting.
  Models 420-626 and 726—4½", 6½" and 7½"—Four-Stud Mounting.

Ruggedized Series
- Ruggedized to Meet Tough Environmental Standards, Including—Temperature and Humidity Extremes, Shock, Vibration, Thermal Shock and Immersion.
- Sizes:
  1½", 2½", and 3½"
- Case:
  Thermoplastic Front and Steel Back

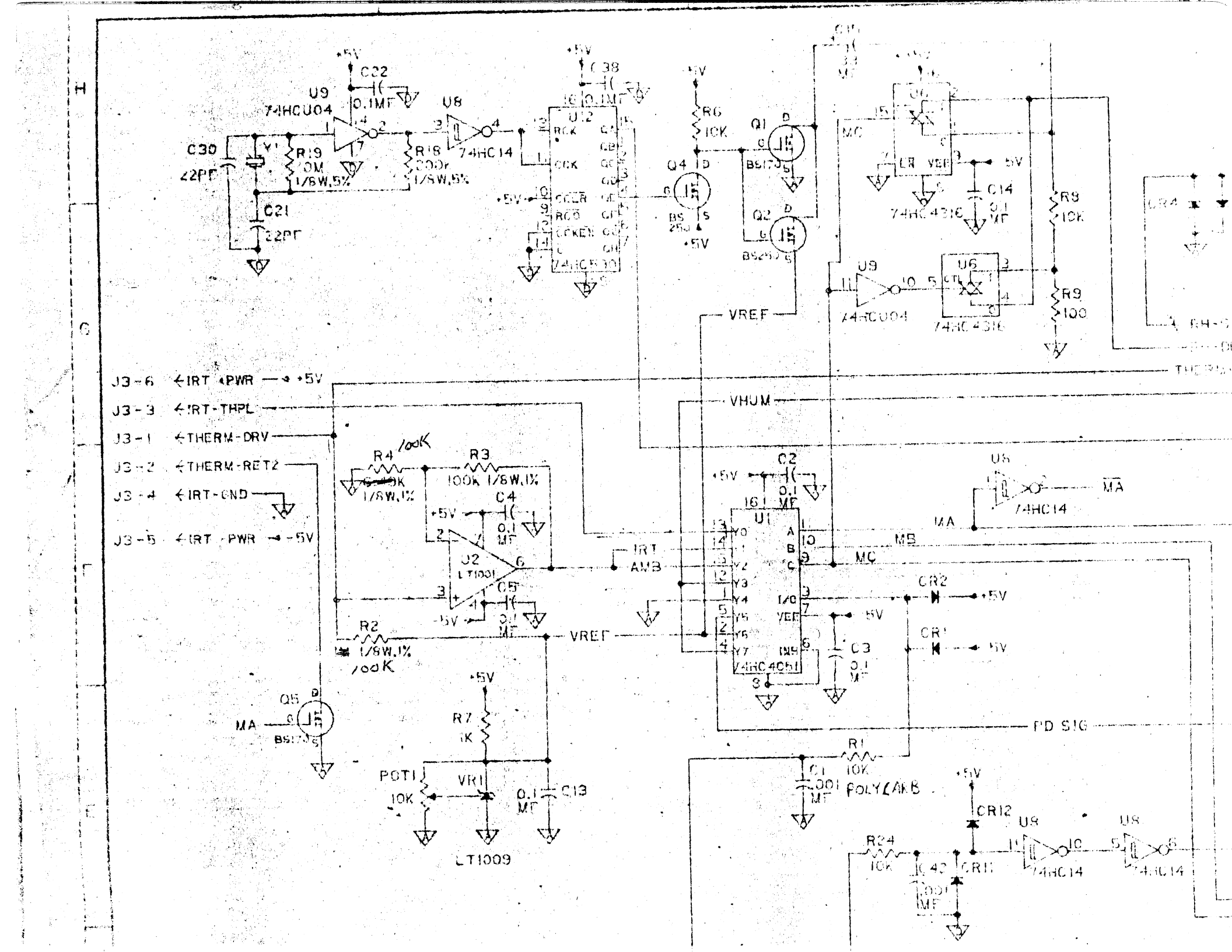


PAGES ON DIGITAL AND ANALOG MULTIMETERS IN SECTION 2900 PGS. D•1236-D•1247.
PAGES ON PANEL METERS IN SECTION 2900 PGS. D•1370-D•1373.

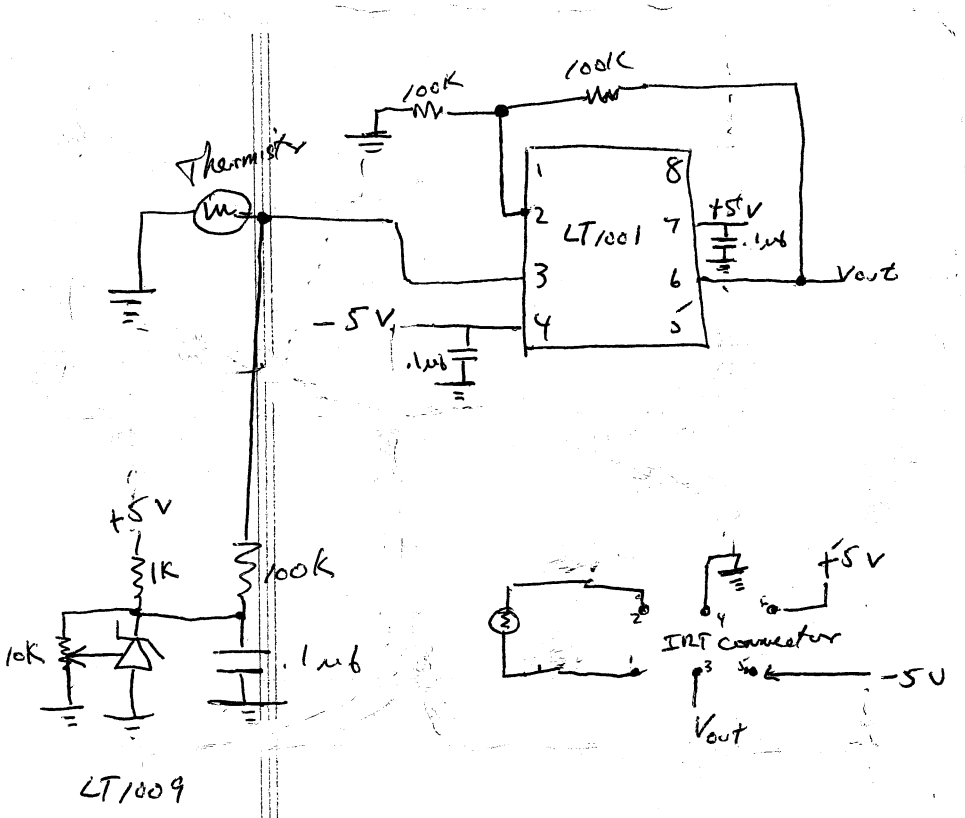
YSI 44032

RESISTANCE VERSUS TEMPERATURE — 40° to +100°

TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES
−40	884.6K	−10	158.0K	+20	37.30K	+50	10.97K	+80	3843
39	830.9K	9	150.0K	21	35.70K	51	10.57K	81	3720
38	780.8K	8	142.4K	22	34.17K	52	10.18K	82	3602
37	733.9K	7	135.2K	23	32.71K	53	9807	83	3489
36	690.2K	6	128.5K	24	31.32K	54	9450	84	3379
35	649.3K	5	122.1K	25	30.00K	55	9109	85	3273
34	611.0K	4	116.0K	26	28.74K	56	8781	86	3172
33	575.2K	3	110.3K	27	27.54K	57	8467	87	3073
32	541.7K	2	104.9K	28	26.40K	58	8166	88	2979
31	510.4K	− 1	99.80K	29	25.31K	59	7876	89	2887
−30	481.0K	0	94.98K	+30	24.27K	+60	7599	+90	2799
29	453.5K	+ 1	90.41K	31	23.28K	61	7332	91	2714
28	427.7K	2	86.09K	32	22.33K	62	7076	92	2632
27	403.5K	3	81.99K	33	21.43K	63	6830	93	2552
26	380.9K	4	78.11K	34	20.57K	64	6594	94	2476
25	359.6K	5	74.44K	35	19.74K	65	6367	95	2402
24	339.6K	6	70.96K	36	18.96K	66	6149	96	2331
23	320.9K	7	67.66K	37	18.21K	67	5940	97	2262
22	303.3K	8	64.53K	38	17.49K	68	5738	98	2195
21	286.7K	9	61.56K	39	16.80K	69	5545	99	2131
−20	271.2K	+10	58.75K	+40	16.15K	+70	5359	+100	2069
19	256.5K	11	56.07K	41	15.52K	71	5180		
18	242.8K	12	53.54K	42	14.92K	72	5007		
17	229.8K	13	51.13K	43	14.35K	73	4842		
16	217.6K	14	48.84K	44	13.80K	74	4682		
15	206.2K	15	46.67K	45	13.28K	75	4529		
14	195.4K	16	44.60K	46	12.77K	76	4381		
13	185.2K	17	42.64K	47	12.29K	77	4239		
12	175.6K	18	40.77K	48	11.83K	78	4102		
11	166.6K	19	38.99K	49	11.39K	79	3970		


J3-6 ← IRT +PWR → +5V
J3-3 ← IRT-THPL
J3-1 ← THERM-DRV
J3-2 ← THERM-RET2
J3-4 ← IRT-GND
J3-5 ← IRT -PWR → -5V
U9 74HCU04
U8 74HC14
U12 74HC390
C30 22PF
C21 22PF
R19 10M 1/8W,5%
R18 200K 1/8W,5%
C22 0.1MF
C38 0.1MF
R6 10K
Q1 BS170
Q2 BS250
Q4 BS250
VREF
VHUM
U6 74HC4316
R9 10K
R9 100
R4 100K
R3 100K 1/8W,1%
C4 0.1 MF
U2 LT1001
C5 0.1 MF
R2 1/8W,1% 100K
IRT AMB
C2 0.1 MF
U1 74HC4051
MA
MB
MC
CR2
CR1
C3 0.1 MF
PD SIG
Q5 BS170
R7 1K
POT1 10K
VR1
C13 0.1 MF
LT1009
R1 10K
C1 .001 MF POLYCARB
R24 10K
CR12
CR11
C43 .001 MF

IRT Thermister Schematic



SENSOR PCB TEMPERATURE READING ERROR
(RER 330016)

The incorrect temperature readings on sensor PCBs is not caused by A.C. noise as such on the input of the thermistor amplifier. The primary source of error is a DC offset difference of the input signals from the two thermistors. The A.C. noise signal is, however, higher than good P.C. design standards. This is due to close proximity of the amplifier input line to noise sources on the board. Noise will not be a significant problem in the Scheduler because of the RC network of R1 and C1, which restores the signal to a normalized DC level. Also, the common mode rejection ratio of this A to D converter is high (typically 86 decibles).

The fundamental problem of DC offset error is due to the fact that the thermistor circuit uses a 1 MEG resistor, which yields very low current (2.5 microamp) and very low voltages as follows for thermistor range over temperature.

Attenuator Resistor (R2) Value VS Amplifier Input Voltage

100 K	1 MEG	Thermistor Resistance
.9247 DCV	.1386	58.7 K (10^{o}C)
.5769	.0728	30.00 K (25^{o}C)
.1370	.0144	5799 (60^{o}C)

As shown in the table, amplifier input voltage can be very low for low thermistor resistance. A cost effective solution to the problem is to increase the voltage at the tap of the attenuator by lowering the value of R2 to 100K and reducing the gain of U2 from 16.4 to 2 by changing the value of R4 to 100K. (See Figure A) This increase in thermistor power should not increase self heat error of the thermistor to an objectionable value as shown:

Power Dissipation of Thermistor @ 60^{o}C (worst case)

$$P = \frac{E^2}{R} = \frac{.1370^2}{5799} = 3.2 \text{ uW}$$

Thermistor Power Dissipation

Self Heat Error Based on 1 MW/Degree C in Air (Worst Case)

$$\frac{3.2 \text{ uW}}{.001} = .0032$$

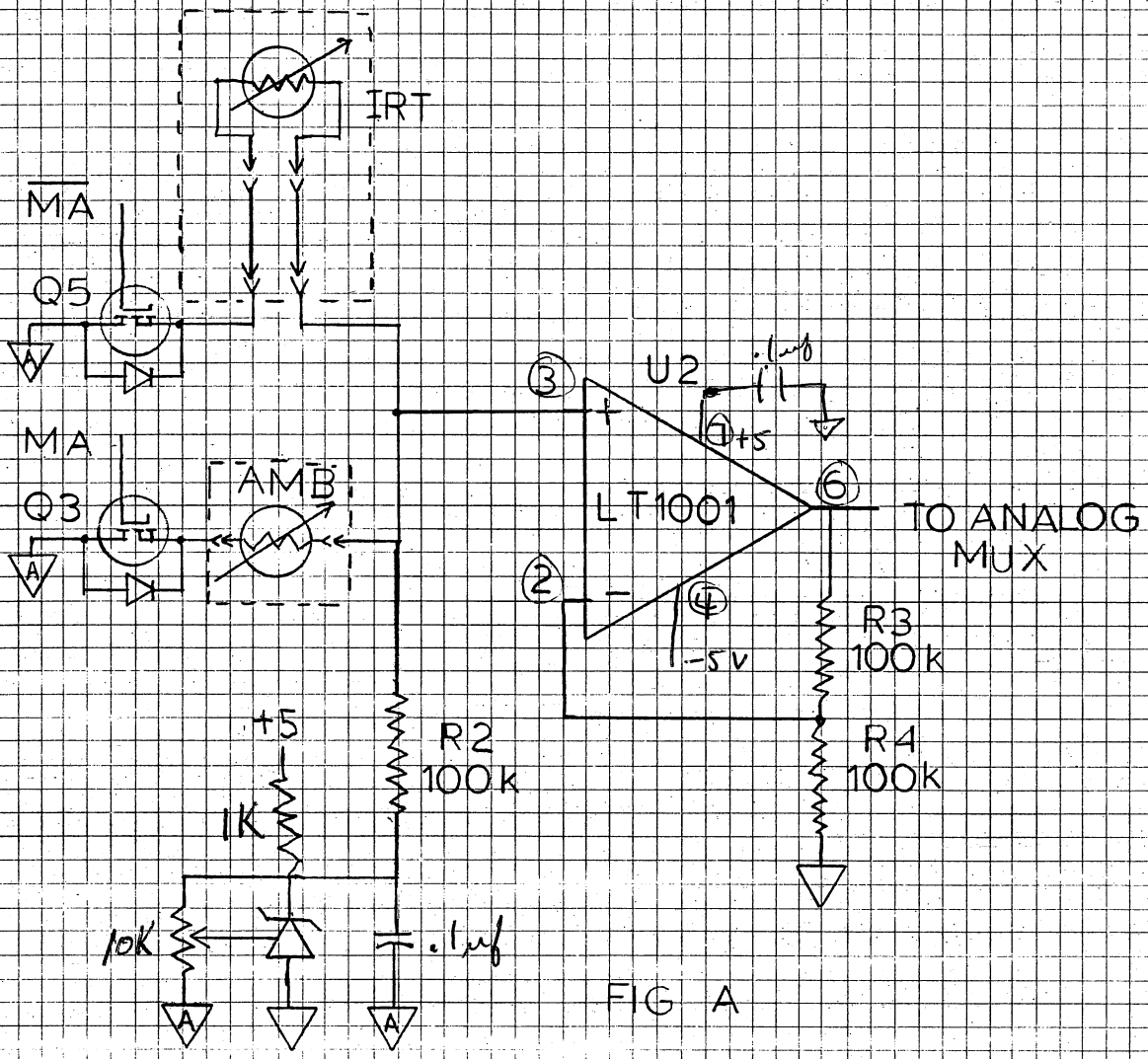

IRT
$\overline{MA}$
Q5
MA
Q3
AMB
U2
.1uf
+5
LT1001
TO ANALOG MUX
-5v
R3
100k
R4
100k
R2
100k
+5
1K
10K
.1uf

FIG A

The effect of this change is to make the offset error a much lower statistical component of the signal (improve signal to error voltage ratio.) The following is test data, which is a comparison of a production failure unit to a working sensor PCB. Data is shown for values defore and after the design change.

Sensor PCB 1 MEG Attenuator amp Gain = 16.4

A = Standard Oil "control" sensor PCB
B = MOOG production s/n 243

Sensor PCB	Indcted TRH	Temp TIR	Amplifier Outputs TRH	Amplifier Outputs TIR	Amplifier Inputs TRH	Amplifier Inputs TIR	Input Difference DCV	Input Difference %
A	25	25	1.1947	1.1952	.0735	.0735	.0	0
B	25.1	25.5	1.1948	1.1776	.0735	.0719	.0016	2.2

After sensor PCB with attenuator resistor change to 100K amp gain = 2

Sensor PCB	Indcted TRH	Temp TIR	Amplifier Outputs (Volts) TRH	Amplifier Outputs (Volts) TIR	Amplifier Inputs TRH	Amplifier Inputs TIR	Input Difference DCV	Input Difference %
A	24.9	24.9	1.1560	1.1562	.5769	.5770	.0001	.01
B	24.9	24.9	1.1561	1.1535	.5769	.5754	.0015	.26

This hardware change requires a change in software, specifically some look-up table values.

The look-up table in software changes because of the different amplifier output for various thermistor readings. The look-up table is generated from the following formula:

$$Kt = \frac{Gain * Rt * 4000}{10^5 + Rt}$$

Where: Gain = U2 Circuit gain
Rt = Thermistor resistance at selected temperature
Kt = Expected A/D counts at selected temperature

Table 1 shows A to D count values for various temperature readings.

Conclusions:

The resistor changes in the U2 amplifier will accomplish the following:

1. Allow sensor board to more accurately read thermistors
2. Allow Scheduler to take temperature data down to $0^{o}C$
3. Reduce noise on the output of the amplifier
4. Significantly reduce effects of high humidity error due to increased leakage

OBS	TEMP	IMP	RESIST	COUNT
1	0	94.980	94980	3897.02
2	1	90.410	90410	3798.54
3	2	86.090	86090	3701.00
4	3	81.990	81990	3604.15
5	4	78.110	78110	3508.39
6	5	74.440	74440	3413.90
7	6	70.960	70960	3320.54
8	7	67.660	67660	3228.44
9	8	64.530	64530	3137.66
10	9	61.560	61560	3048.28
11	10	58.750	58750	2960.63
12	11	56.070	56070	2874.09
13	12	53.540	53540	2789.63
14	13	51.130	51130	2706.54
15	14	48.840	48840	2625.10
16	15	46.670	46670	2545.58
17	16	44.600	44600	2467.50
18	17	42.640	42640	2391.48
19	18	40.770	40770	2316.97
20	19	38.990	38990	2244.19
21	20	37.300	37300	2173.34
22	21	35.700	35700	2104.64
23	22	34.170	34170	2037.42
24	23	32.710	32710	1971.82
25	24	31.320	31320	1908.01
26	25	30.000	30000	1846.15
27	26	28.740	28740	1785.93
28	27	27.540	27540	1727.46
29	28	26.400	26400	1670.89
30	29	25.310	25310	1615.83
31	30	24.270	24270	1562.40
32	31	23.260	23260	1509.65
33	32	22.330	22330	1460.31
34	33	21.430	21430	1411.84
35	34	20.570	20570	1364.85
36	35	19.740	19740	1318.86
37	36	18.960	18960	1275.05
38	37	18.210	18210	1232.38
39	38	17.490	17490	1190.91
40	39	16.800	16800	1150.68
41	40	16.150	16150	1112.35
42	41	15.520	15520	1074.79
43	42	14.920	14920	1038.64
44	43	14.350	14350	1003.94
45	44	13.800	13800	970.12
46	45	13.280	13280	937.85
47	46	12.770	12770	905.91
48	47	12.290	12290	875.59
49	48	11.830	11830	846.28
50	49	11.390	11390	818.03
51	50	10.970	10970	790.84
52	51	10.570	10570	764.76
53	52	10.180	10180	739.15
54	53	9.807	9807	714.49

TABLE 1

OBS	TEMP	IMP	RESIST	COUNT
55	54	9.450	9450	690.726
56	55	9.109	9109	667.883
57	56	8.781	8781	645.775
58	57	8.467	8467	624.485
59	58	8.166	8166	603.961
60	59	7.876	7876	584.078
61	60	7.599	7599	564.987

Further Recommendations:

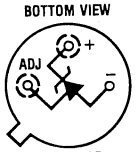
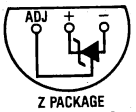
1. Carefully test leakage of mosfets Q3 and Q5 as per data sheet specifications
2. Test resistance of amplifier input runs to adjacent runs on all raw P.C. boards to insure good P.C. process and materials
3. Update MOOG test work sheet #A91575 REVA Section 3.4.3, 3.4.4 and 3.4.6 to show a tighter tolerance to test closer to Scheduler specifications < +/- .36°F. Update section 3.42 to adjust pot for 1.1568 +/- .5 mV
4. Review tester hardware. All sensor lines should be kept as short as possible, use shielded lines and insure tester power supply is not adding noise to Scheduler power supplies

by using a 30 K precision resistor (exactly 30K)

ABSOLUTE MAXIMUM RATINGS

Reverse Current 20mA
Forward Current 10mA
Operating Temperature Range
LT1009M ..... −55°C to 125°C
LT1009C ..... 0°C to 70°C
Storage Temperature Range
LT1009M and C ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.)..... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
BOTTOM VIEW  H PACKAGE TO-46 METAL CAN	LT1009MH LT1009CH
BOTTOM VIEW  Z PACKAGE TO-92 PLASTIC	LT1009CZ

ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS		LT1009M MIN	LT1009M TYP	LT1009M MAX	LT1009C MIN	LT1009C TYP	LT1009C MAX	UNITS
V_Z	Reverse Breakdown Voltage	$T_A = 25°C$, $I_R = 1mA$		2.495	2.500	2.505	2.495	2.500	2.505	V
$\frac{\Delta V_Z}{\Delta I_R}$	Reverse Breakdown Change with Current	$400\mu A \le I_R \le 10mA$			2.6	6		2.6	10	mV
			●		3	10		3	12	mV
r_Z	Reverse Dynamic Impedance	$I_R = 1mA$			0.2	0.6		0.2	1.0	Ω
			●		0.4	1		0.4	1.4	Ω
$\frac{\Delta V_Z}{\Delta Temp}$	Temperature Stability	$T_{MIN} \le T_A \le T_{MAX}$	●			15		1.8	4	mV
	Average Temperature Coefficient	$0°C \le T_A \le 70°C$			15	25		15	25	ppm/°C
		$-55°C \le T_A \le 125°C$ (Note 1)			25	35				ppm/°C
$\frac{\Delta V_Z}{\Delta Time}$	Long Term Stability	$T_A = 25°C \pm 0.1°C$, $I_R = 1mA$			20			20		ppm/kHr

The ● denotes the specifications which apply over full operating temperature range.

Note 1: Average temperature coefficient is defined as the total voltage change divided by the specified temperature range.

LINEAR TECHNOLOGY

TYPICA
Rever
REVERSE CURRENT (A)
Dyna
DYNAMIC IMPEDANCE (Ω)
SCHE

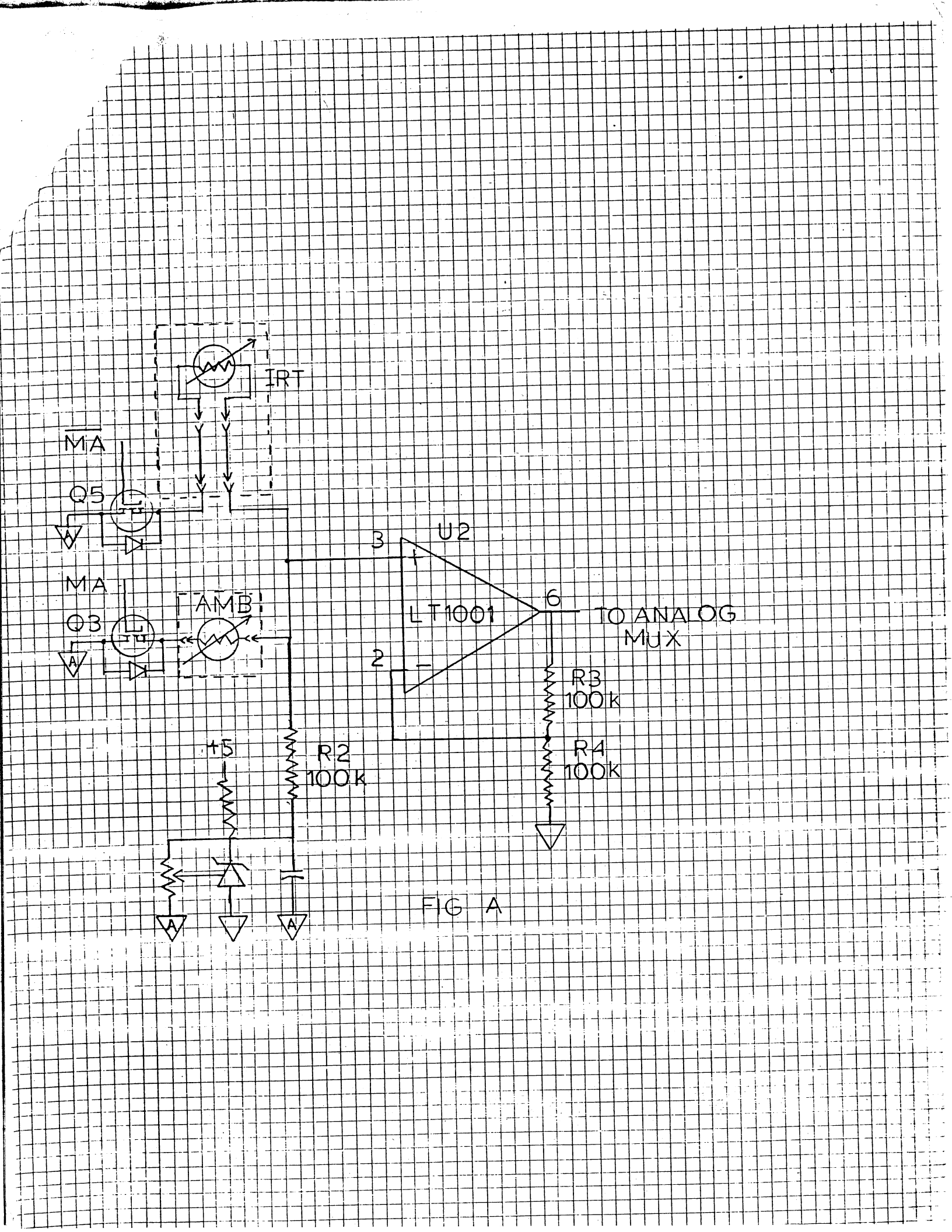
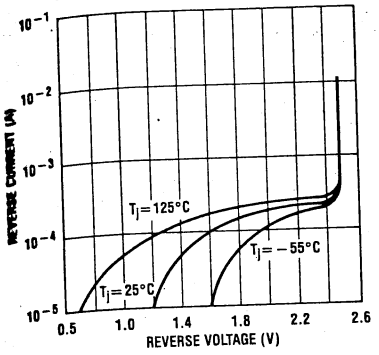

IRT
$\overline{MA}$
Q5
MA
AMB
Q3
U2
3
2
6
LT1001
TO ANALOG MUX
R3 100k
R4 100k
R2 100k
+5

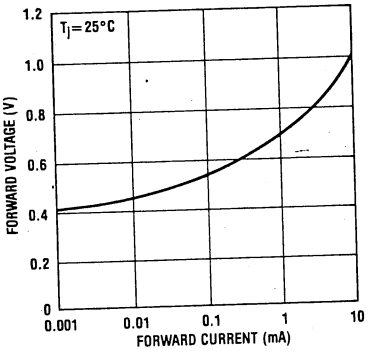
FIG A

TYPICAL PERFORMANCE CHARACTERISTICS

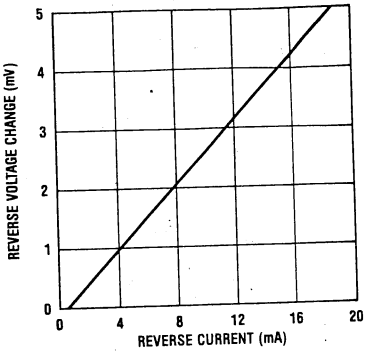
Reverse Characteristics



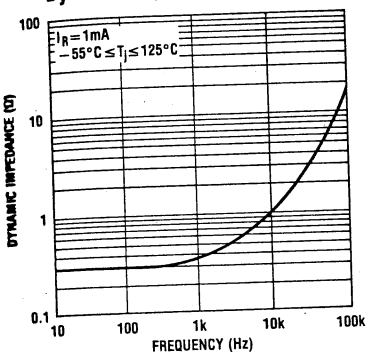
Forward Characteristics



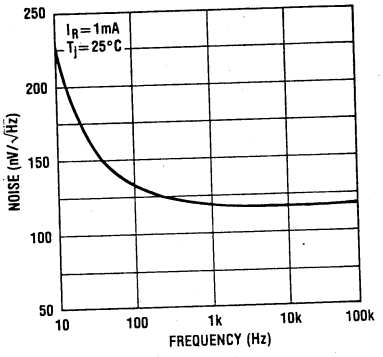
Reverse Voltage Change



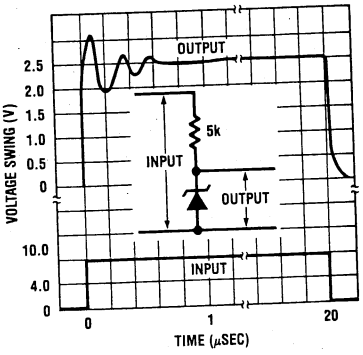
Dynamic Impedance



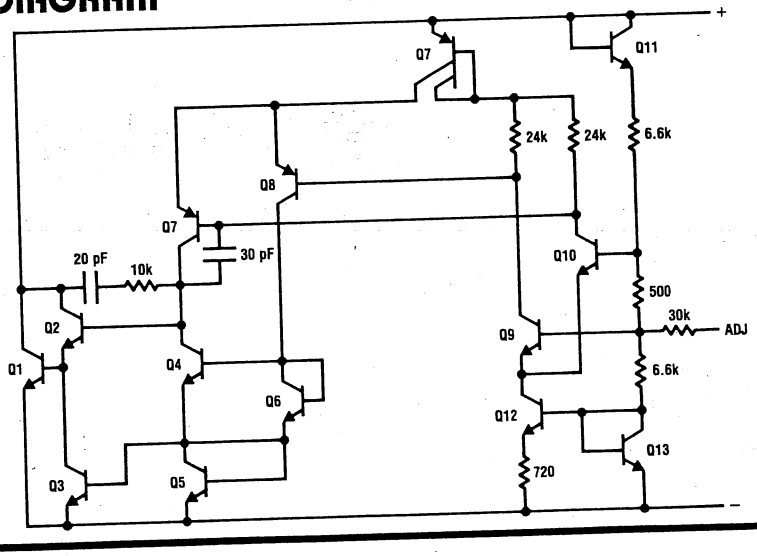
Zener Noise Voltage



Response Time



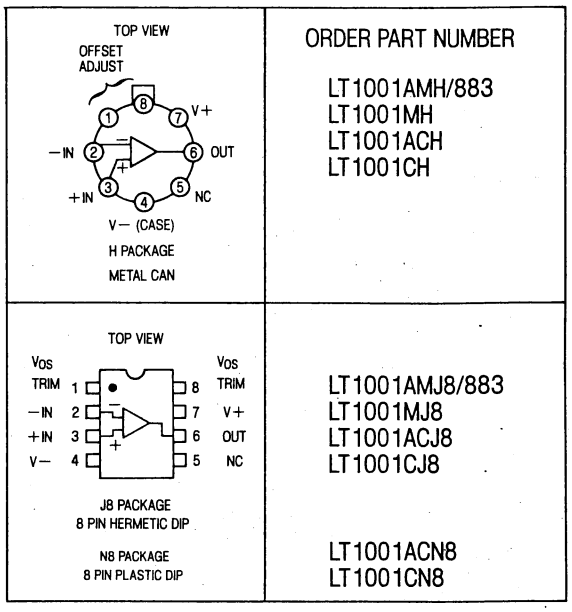
SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±22V
Differential Input Voltage ..... ±30V
Input Voltage ..... ±22V
Output Short Circuit Duration ..... Indefinite
Operating Temperature Range
LT1001AM/LT1001M ..... −55°C to 150°C
LT1001AC/LT1001C ..... 0°C to 125°C
Storage: All Devices ..... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

PACKAGE/ORDER INFORMATION



ORDER PART NUMBER

LT1001AMH/883
LT1001MH
LT1001ACH
LT1001CH

LT1001AMJ8/883
LT1001MJ8
LT1001ACJ8
LT1001CJ8

LT1001ACN8
LT1001CN8

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $T_A = 25°C$, unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS	LT1001AM/883 LT1001AC MIN	LT1001AM/883 LT1001AC TYP	LT1001AM/883 LT1001AC MAX	LT1001M/LT1001C MIN	LT1001M/LT1001C TYP	LT1001M/LT1001C MAX	UNITS
V_{OS}	Input Offset Voltage	Note 1 LT1001AM/883		7	15		18	60	μV
		LT1001AC		10	25				
$\frac{\Delta V_{OS}}{\Delta \text{ Time}}$	Long Term Input Offset Voltage Stability	Notes 2 and 3		0.2	1.0		0.3	1.5	μV/month
I_{OS}	Input Offset Current			0.3	2.0		0.4	3.8	nA
I_b	Input Bias Current			±0.5	±2.0		±0.7	±4.0	nA
e_n	Input Noise Voltage	0.1Hz to 10Hz (Note 2)		0.3	0.6		0.3	0.6	μV_{p-p}
e_n	Input Noise Voltage Density	f_o = 10Hz (Note 5)		10.3	18.0		10.5	18.0	$nV\sqrt{Hz}$
		f_o = 1000Hz (Note 2)		9.6	11.0		9.8	11.0	
A_{VOL}	Large Signal Voltage Gain	$R_L \geq 2k\Omega$, $V_o = \pm 12V$	450	800		400	800		V/mV
		$R_L \geq 1k\Omega$, $V_o = \pm 10V$	300	500		250	500		
CMRR	Common Mode Rejection Ratio	$V_{CM} = \pm 13V$	114	126		110	126		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 18V$	110	123		106	123		dB
R_{in}	Input Resistance Differential Mode	(Note 4)	30	100		15	80		MΩ
	Input Voltage Range		±13	±14		±13	±14		V
V_{OUT}	Maximum Output Voltage Swing	$R_L \geq 2k\Omega$	±13	±14		±13	±14		V
		$R_L \geq 1k\Omega$	±12	±13.5		±12	±13.5		
S_R	Slew Rate	$R_L \geq 2k\Omega$ (Note 4)	0.1	0.25		0.1	0.25		V/μs
GBW	Gain-Bandwidth Product	(Note 4)	0.4	0.8		0.4	0.8		MHz
P_d	Power Dissipation	No load		46	75		48	80	mW
		No load, $V_s = \pm 3V$		4	6		4	8	

See Notes on page 3.

LINEAR TECHNOLOGY

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IM/GP/BC 1085 50M

FEATURES

- *Guaranteed* Low Offset Voltage
  - LT1001AM 15μV max
  - LT1001C 60μV max
- *Guaranteed* Low Drift
  - LT1001AM 0.6μV/°C max
  - LT1001C 1.0μV/°C max
- *Guaranteed* Low Bias Current
  - LT1001AM 2nA max
  - LT1001C 4nA max
- *Guaranteed* CMRR
  - LT1001AM 114dB min
  - LT1001C 110dB min
- *Guaranteed* PSRR
  - LT1001AM 110dB min
  - LT1001C 106dB min
- Low Power Dissipation
  - LT1001AM 75mW max
  - LT1001C 80mW max
- Low Noise 0.3μV_{p-p}

APPLICATIONS

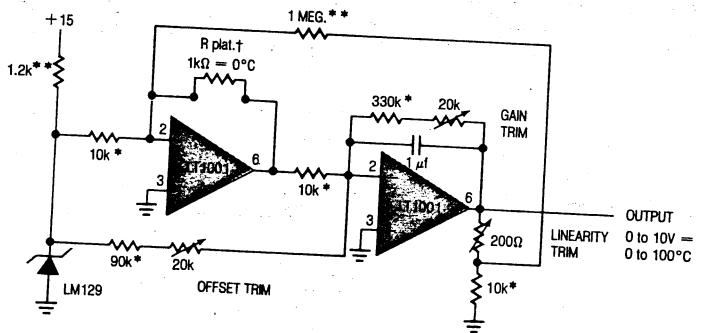
- Thermocouple amplifiers
- Strain gauge amplifiers
- Low level signal processing
- High accuracy data acquisition

DESCRIPTION

The LT1001 significantly advances the state-of-the-art of precision operational amplifiers. In the design, processing, and testing of the device, particular attention has been paid to the optimization of the entire distribution of several key parameters. Consequently, the specifications of the lowest cost, commercial temperature device, the LT1001C, have been dramatically improved when compared to equivalent grades of competing precision amplifiers.

Essentially, the input offset voltage of all units is less than 50μV (see distribution plot below). This allows the LT1001AM/883 to be specified at 15μV. Input bias and offset currents, common-mode and power supply rejection of the LT1001C offer guaranteed performance which were previously attainable only with expensive, selected grades of other devices. Power dissipation is nearly halved compared to the most popular precision op amps, without adversely affecting noise or speed performance. A beneficial by-product of lower dissipation is decreased warm-up drift. Output drive capability of the LT1001 is also enhanced with voltage gain guaranteed at 10 mA of load current. For similar performance in a dual precision op amp, with guaranteed matching specifications, see the LT1002. Shown below is a platinum resistance thermometer application.

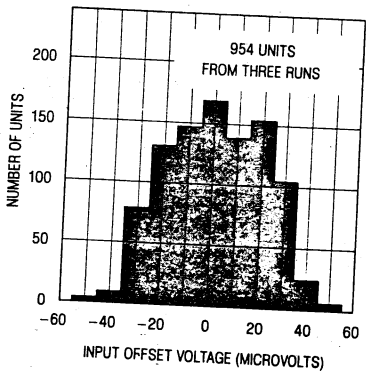
Linearized Platinum Resistance Thermometer with ±0.025°C Accuracy Over 0 to 100°C



* ULTRONIX 105A WIREWOUND
** 1% FILM
† PLATINUM RTD 118MF (ROSEMOUNT, INC.)

‡ Trim sequence: trim offset (0°C = 1000.0Ω), trim linearity (35°C = 1138.7Ω), trim gain (100°C = 1392.6Ω). Repeat until all three points are fixed with ±.025°C.

Typical Distribution of Offset Voltage
V_S = ±15V, T_A = 25°C



STANDARD OIL
ENGINEERED MATERIALS

$T_B = 45°C$

Sensor	ER	Volts	TD	Correction factor
~~#50~~	44.3	.6318	27.1	317
93	44.2	.6337	26.9	369.7
112	44.3	0.6437	26.9	365.7
215	44.4	0.6462	26.8	277.7
217	44.6	0.6606	26.7	458.1
49	44.4	0.6612	26.7	219.1
84	46.0	0.7168	26.7	540.3
170	44.6	0.6518	26.8	405.8
241	44.4	0.6037	27.9	408.6
5	44.4	0.6237	27.4	428.7
22	44.4	0.6313	27.2	319.8
18	44.4	0.6387	27.0	445.9
94	44.3	0.6337	27.0	321.6
29	44.3	0.6268	27.2	420.8
141	44.3	0.6149	27.5	327.0

STANDARD OIL
ENGINEERED MATERIALS

$T_B = 45°C$

Sensor	~~ER~~ ERT	volts
93	44.4	0.6706
141	44.8	0.6812
50	44.7	0.6837
112	44.6	0.6731
215	44.6	0.6731
~~217~~	~~53.5~~	~~1.05~~
~~#~~149	44.7	0.6849
~~84~~	~~unstable~~	
~~170~~	~~unstable~~	
~~241~~	~~unstable~~	
~~5~~	~~unstable~~	

1 1 1
1 1 1 (2)

	Error at 0.013	error at 0.006
219.1	2.8	1.3
277.7	3.6	1.7
317.7	4.1	1.9
319.8	4.2	1.9
321.6	4.2	1.9
327.0	4.3	2.0
358.7	4.7	2.2
365.7	4.8	2.2
369.7	4.8	2.2
		2.4
405.8	5.3	2.5
408.6	5.3	2.5
420.8	5.5	2.6
428.7	5.6	2.7
445.9	5.8	2.7
488.1	6.0	3.2
540.3	7.0	

Average

387.8

STANDARD OIL
ENGINEERED MATERIALS

Sensor T_D T_B V rate

rate $\angle$ − 0.022

0.99945 Dynamic
−0.0328 * DIR
58.3594 * Dir * RATE
−1.24826 * Dyn. * rate

0.99916 Dyn.
−0.067227 DIR
58.4320129 * Dir * rate
~~Dyn~~
−0.781718 * Dyn rate

$IRT = \underset{30}{\text{Static}} - x \cdot \text{rate}$

$IRT = 30 - x \text{ rate}$

$(IRT - 30) = -x \text{ rate}$

$30 - IRT = x \text{ rate}$

$\frac{30 - IRT}{\text{rate}} = x = \cancel{252x} = (252 + x)$

$\frac{30 - IRT}{\text{rate}} + 252 = x$

(IRT − 30)

(28.5 − 30) (−1.5)

DATE: _____

TO: _____

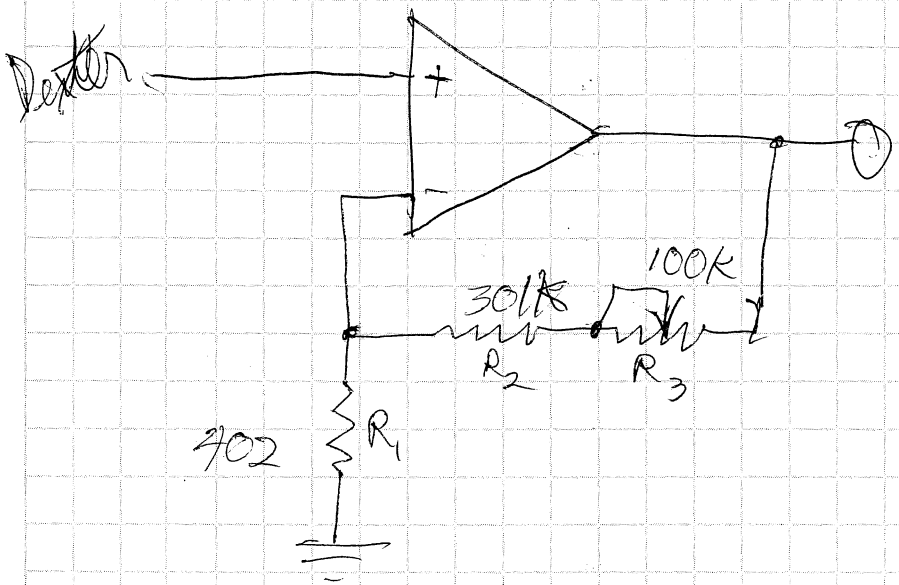
FROM: _____

SUBJECT: _____

CAM RPC ELECTRONICS

750 → 1000

$V_o = \frac{(R_2 + R_3)}{R_1} + 1$



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620 Alpha Drive
412-782-3770

CLEVELAND, OHIO
749 Miner Road
216-461-4700

ROCHESTER, N.Y.
1020 Lehigh Station Road
716-865-2080

PHILADELPHIA, PA
21119 E. Cumberland St.
215-739-4095

LONGWOOD, (Orlando, FL)
1712 North State Route 427
305-834-2031
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SYRACUSE, N.Y.
1-800-462-6894

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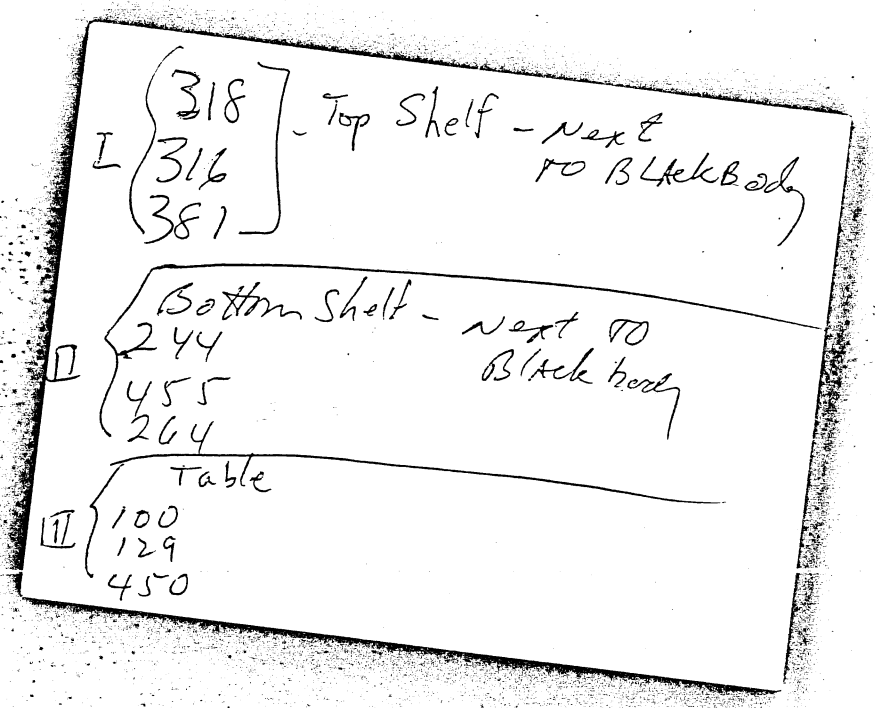
1-800-242-1733

YOUR HIGH TECH CONNECTION

FOR AMF Potter & Brumfield Relays


I
318
316
381
Top Shelf - Next to Blackboard
I
Bottom Shelf - Next to Black board
244
455
264
II
Table
100
129
450

```
1591        /*****************************************************************************
1592         **
1593         ** CONVERT_STD: Calculate standard deviation
1594         **
1595         **      CALL SEQUENCE: std = convert_std(sum_of_sqr, sqr_of_sum, n)
1596         **
1597         **      INPUT:     sum         = Sum of samples
1598         **                 sum_of_sqr  = Sum of samples ** 2
1599         **                 n           = number of samples
1600         **
1601         **      RETURN:    std         = Calculated standard deviation
1602         **
1603         *****************************************************************************/
1604
1605        float convert_std(sum, sum_of_sqr, n)
1606 0A27   float   sum;
1607        float   sum_of_sqr;
1608        int     n;
1609 0A27   {
1610            float std;
1611
1612 0A27       float num = (float)n;
1613
1614 0A3F       if (n > 1)
1615 0A59       {
1616 0A59           std = power(sum, 2.0) / num;
1617 0AA4           std = (sum_of_sqr - std) / (num - 1.0);
1618 0AEF           std = power(std, 0.5);
1619            }
1620            else
1621 0B27       {
1622 0B27           std = 0.0;
1623            }
1624 0B37       std = floor(std * 100.0) / 100.0;
1625
1626 0B76       return(std);
1627        }
1628
```

```
1527
1528        /*****************************************************************************
1529         **
1530         ** CONVERT_STRESS: Calculate stress index
1531         **
1532         **      CALL SEQUENCE: stress = convert_stress(crop, trh, rh, ir)
1533         **
1534         **      INPUT:    crop      = Currently selected crop number
1535         **                trh       = Pointer to ambient air temperature (deg. C)
1536         **                rh        = Pointer to relative humidity (%)
1537         **                ir        = Pointer to infra-red radiation (deg. C)
1538         **
1539         **      RETURN:   stress    = Calculated stress index
1540         **
1541         *****************************************************************************/
1542
1543        float convert_stress(crop_num,trh,rh,ir)
1544 078B   short    crop_num;
1545        float    trh;
1546        float    rh;
1547        float    ir;
1548 078B   {
1549            int    i;
1550            float  stress, svp, vpd, min, percent;
1551            float  crop_intercept, crop_slope, crop_max;
1552
1553
1554 078B       crop_intercept = crop_tbl[crop_num].cr_intercept;
1555 07B4       crop_slope     = crop_tbl[crop_num].cr_slope;
1556 07DD       crop_max       = crop_tbl[crop_num].cr_max;
1557
1558            /*
1559               ..... Calculate Saturation Vapor Pressure
1560               ..... at current ambient temperature
1561            */
1562
1563 0806       svp = 0.61078 * exp((17.2693882 * trh) / (trh + 237.3));
1564
1565            /*
1566               ..... Calculate Vapor Pressure Deficit at current
1567               ..... Saturation Vapor Pressure and Relative Humidity
1568            */
1569
1570 0863       vpd     = (1 - (rh/100.0)) * svp;
1571
1572            /*
1573               ..... Calculate upper and lower baseline cutoffs
1574            */
1575
1576 08A7       if (vpd <= 1.0)
1577 08BD       {
1578 08BD            min = crop_intercept + crop_slope;
1579            }
1580 08ED       else if (vpd >= 6.0)
1581 090D       {
1582 090D            min = (crop_intercept + crop_slope + 6.0) - (vpd - 6.0);
1583            }
1584            else
1585 0967       {
1586 0967            min = crop_intercept + (crop_slope * vpd);
1587            }
1588
1589            /*
1590               ..... Calculate CWSI (Crop Water Stress Index)
1591            */
```

```
1592
1593 09A5          stress  = ((ir - trh) - min) / (error_max - min);
1594 0A05          stress *= 10.0;
1595
1596 0A22          return(stress);
1597          }
1598
```

```
1238          /*****************************************************************************
1239           **
1240           ** CONVERT_IR():  Convert counts to IR temperature
1241           **
1242           **       CALL SEQUENCE: ir = convert_ir(count, tir, rate_of_change);
1243           **
1244           **       INPUT:    count           = IR counts read from A/D (corrected),
1245           **                 tir             = Detector temperature (current)
1246           **                 rate_of_change = IR detector temperature rate of change
1247           **                                  over a minimum of last 90 seconds
1248           **
1249           **       RETURN:   ir        = IR temperature (deg. C),
1250           **
1251           *****************************************************************************/
1252
1253          float convert_ir(ir_cnt, tir, rate_of_change)
1254   000F   int        ir_cnt;
1255          float      tir;
1256          float      rate_of_change;
1257   000F   {
1258              float  static_ir, ir, irt, v, v2, v3;
1259
1260              /*
1261                 ..... STATIC (Tir not changing) equations:
1262                 .....
1263                 ..... IRT       = Tir + (c1 * V) + (c2 * V^2) + (c3 * v^3)
1264                 ..... STATIC_IR= c4 + (c5 * IRT) + (c6 * Tir) + (c7 * V) + (c8 * V * IRT)
1265                 .....
1266                 ..... DYNAMIC (Tir changing) equations:
1267                 .....
1268                 ..... IR        = STATIC_IR + (c9 * DT)
1269                 ..... DT        = [ Tir(current) - Tir(delta time) ] / delta time
1270                 .....
1271                 ..... Tir = IR detector temperature in desrees Centigrade
1272                 .....
1273                 .....                          Full Scale A/D Volts                    2.5V
1274                 ..... V    = Ir Counts * ---------------------- = Ir counts * -----------
1275                 .....                          Full Scall A/D Counts           4000 counts
1276                 .....
1277                 ..... c1 = 29.19715611, c2 = -2.81682940, c3 =    0.27688208
1278                 ..... c4 = -0.6622034,  c5 = 0.54889654,  c6 =    0.47212242
1279                 ..... c7 = 15.33622049, c8 = -0.07010936, c9 = -366.76
1280              */
1281
1282              /*
1283                 ..... Calculat IR in static environment
1284              */
1285
1286   000F       v  = (float)ir_cnt * 0.000625;
1287   0034       v2 = power(v, 2.0);
1288   006A       v3 = power(v, 3.0);
1289
1290   00A0       irt         = tir + (29.19715611 * v) - (2.816894 * v2) + (0.27688208 * v3);
1291   0116       static_ir   = -0.6622034 + (0.54889654 * irt) + (0.47212242 * tir);
1292   016D       static_ir  += ( (15.33622049 * v) - (0.07010936 * v * irt) );
1293
1294              /*
1295                 ..... Correct for dynamic environment
1296              */
1297
1298   01CA       ir           = static_ir - (366.76 * rate_of_change);
1299
1300              /*
1301                 ... Return final IR value
1302              */
```

```
1303
1304 01F8          return(ir);
1305          }
1306
1307
```

```
;*****************************************************************************
;
; $Header$
;
; CROP.DAT:     This module contains the crop identification tables.
;                       This module is is the only module in the Irrigation
;                       Scheduler Software Package which needs to be changed
;                       in order to add, delete, or modify the crop selection
;                       for a particular version of the Irrigation Scheduler.
;
;                       When a change is made, no recompilation is needed. The
;                       crop configuration package reads this file and creates
;                       the needed tables.
;
;*****************************************************************************
;
;** $Log$
;
;*****************************************************************************

;     crop      crop    intercept   slope         irrigation threshold    bar graph
;     name      stage       (A)       (B)    max  ref. line  low   high    window
;   ---------   -----   ---------   -----   ---   ---------  ----  ----    -------
    ALFALFA   ,   0,      2.040,   -2.020,  4.0,     1.5,     -3.0,  7.0,     8.3,
    BARLEY    ,   1,      2.010,   -2.250,  5.0,     1.5,     -3.0,  7.0,     8.3,
    BARLEY    ,   2,      1.720,   -1.230,  5.0,     1.5,     -3.0,  7.0,     8.3,
    BEETS     ,   0,      5.160,   -2.300,  5.0,     1.5,     -3.0,  7.0,     8.3,
    CHARD     ,   0,      2.460,   -1.880,  5.0,     1.5,     -3.0,  7.0,     8.3,
    CORN      ,   0,      2.670,   -2.059,  4.5,     1.5,     -3.0,  7.0,     8.3,
    COTTON    ,   0,      1.760,   -1.930,  3.0,     1.5,     -3.0,  7.0,     8.3,
    COWPEAS   ,   0,      1.320,   -1.840,  5.0,     1.5,     -3.0,  7.0,     8.3,
    CUCUMBER  ,   0,      3.880,   -2.520,  5.0,     1.5,     -3.0,  7.0,     8.3,
    FIG TREE  ,   0,      4.220,   -1.770,  5.0,     1.5,     -3.0,  7.0,     8.3,
    GRAPES    ,   0,      3.500,   -1.680,  6.0,     1.5,     -3.0,  7.0,     8.3,
    GRN BEAN  ,   0,      2.910,   -2.350,  5.0,     1.5,     -3.0,  7.0,     8.3,
    GUAYULE   ,   0,      1.870,   -1.750,  5.0,     1.5,     -3.0,  7.0,     8.3,
    KOHLRABI  ,   0,      2.010,   -2.170,  5.0,     1.5,     -3.0,  7.0,     8.3,
    LETTUCE   ,   0,      4.180,   -2.960,  5.0,     1.5,     -3.0,  7.0,     8.3,
    MILLET    ,   0,      3.819,   -1.523,  5.0,     1.5,     -3.0,  7.0,     8.3,
    PEAS      ,   0,      2.740,   -2.130,  5.0,     1.5,     -3.0,  7.0,     8.3,
    POTATOES  ,   0,      1.170,   -1.830,  5.0,     1.5,     -3.0,  7.0,     8.3,
    PUMPKIN   ,   0,      0.950,   -1.930,  5.0,     1.5,     -3.0,  7.0,     8.3,
    RICE      ,   0,      1.280,   -2.260,  5.0,     1.5,     -3.0,  7.0,     8.3,
    RUTABAGA  ,   0,      3.750,   -2.660,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SORGHUM   ,   0,      2.530,   -1.960,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SOYBEANS  ,   0,      2.510,   -2.020,  4.0,     1.5,     -3.0,  7.0,     8.3,
    SQUASH H  ,   0,      6.910,   -3.090,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SQUASH Z  ,   0,      2.000,   -1.880,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SGR BEET  ,   0,      2.500,   -1.920,  5.0,     1.5,     -3.0,  7.0,     8.3,
    SUNFLOWR  ,   0,      0.660,   -1.950,  5.0,     1.5,     -3.0,  7.0,     8.3,
    TOMATOES  ,   0,      3.170,   -1.820,  5.0,     1.5,     -3.0,  7.0,     8.3,
    TURF      ,   0,      2.000,   -1.800, 15.0,     1.5,     -3.0,  7.0,     8.3,
    TURNIP    ,   0,      1.940,   -2.260,  5.0,     1.5,     -3.0,  7.0,     8.3,
    WHEAT     ,   1,      0.990,   -2.080,  5.0,     1.5,     -3.0,  7.0,     8.3,
    WHEAT     ,   2,      0.330,   -1.190,  5.0,     1.5,     -3.0,  7.0,     8.3,
    LOW       ,   0,      3.380,   -3.250, 12.0,     1.5,     -3.0,  7.0,     8.3,
    HIGH      ,   0,      3.500,   -1.680,  6.0,     1.5,     -3.0,  7.0,     8.3,
```

```
1508
1509        /*****************************************************************************
1510         **
1511         ** CONVERT_STRESS: Calculate stress index
1512         **
1513         **      CALL SEQUENCE: stress = convert_stress(crop, trh, rh, ir)
1514         **
1515         **      INPUT:    crop      = Currently selected crop number
1516         **                trh       = Pointer to ambient air temperature (deg. C)
1517         **                rh        = Pointer to relative humidity (%)
1518         **                ir        = Pointer to infra-red radiation (deg. C)
1519         **
1520         **      RETURN:   stress    = Calculated stress index
1521         **
1522         *****************************************************************************/
1523
1524        float convert_stress(crop_num,trh,rh,ir)
1525 06B6   short    crop_num;
1526        float    trh;
1527        float    rh;
1528        float    ir;
1529 06B6   {
1530            int    i;
1531            float  stress, svp, vpd, min, percent;
1532            float  crop_intercept, crop_slope, crop_max;
1533
1534
1535 06B6       crop_intercept = crop_tbl[crop_num].cr_intercept;
1536 06DF       crop_slope     = crop_tbl[crop_num].cr_slope;
1537 0708       crop_max       = crop_tbl[crop_num].cr_max;
1538
1539            /*
1540               ..... Calculate Saturation Vapor Pressure
1541               ..... at current ambient temperature
1542            */
1543
1544 0731       svp = 0.61078 * exp((17.2693882 * trh) / (trh + 237.3));
1545
1546            /*
1547               ..... Calculate Vapor Pressure Deficit at current
1548               ..... Saturation Vapor Pressure and Relative Humidity
1549            */
1550
1551 078E       vpd     = (1 - (rh/100.0)) * svp;
1552
1553            /*
1554               ..... Calculate upper and lower baseline cutoffs
1555            */
1556
1557 07D2       if (vpd <= 1.0)
1558 07E8       {
1559 07E8            min = crop_intercept + crop_slope;
1560            }
1561 0818       else if (vpd >= 6.0)
1562 0838       {
1563 0838            min = (crop_intercept + crop_slope + 6.0) - (vpd - 6.0);
1564            }
1565            else
1566 0892       {
1567 0892            min = crop_intercept + (crop_slope * vpd);
1568            }
1569
1570            /*
1571               ..... Calculate CWSI (Crop Water Stress Index)
1572            */
```

```
1574 08D0       stress  = ((ir - trh) - min) / (crof_max - min);
1575 0930       stress *= 10,0;
1576
1577 094D       return(stress);
1578        }
1579
1580
```

SENSOR PCB TEMPERATURE READING ERROR
(RER 330016)

The incorrect temperature readings on sensor PCBs is not caused by A.C. noise as such on the input of the thermistor amplifier. The primary source of error is a DC offset difference of the input signals from the two thermistors. The A.C. noise signal is, however, higher than good P.C. design standards. This is due to close proximity of the amplifier input line to noise sources on the board. Noise will not be a significant problem in the Scheduler because of the RC network of R1 and C1, which restores the signal to a normalized DC level. Also, the common mode rejection ratio of this A to D converter is high (typically 86 decibles).

The fundamental problem of DC offset error is due to the fact that the thermistor circuit uses a 1 MEG resistor, which yields very low current (2.5 microamp) and very low voltages as follows for thermistor range over temperature.

Attenuator Resistor (R2) Value VS Amplifier Input Voltage

100 K	1 MEG	Thermistor Resistance
.9247 DCV	.1386	58.7 K (10^{o}C)
.5769	.0728	30.00 K (25^{o}C)
.1370	.0144	5799 (60^{o}C)

As shown in the table, amplifier input voltage can be very low for low thermistor resistance. A cost effective solution to the problem is to increase the voltage at the tap of the attenuator by lowering the value of R2 to 100K and reducing the gain of U2 from 16.4 to 2 by changing the value of R4 to 100K. (See Figure A) This increase in thermistor power should not increase self heat error of the thermistor to an objectionable value as shown:

Power Dissipation of Thermistor @ 60^{o}C (worst case)

$$P = \frac{E^2}{R} = \frac{.1370^2}{5799} = 3.2 \text{ uW}$$ Thermistor Power Dissipation

Self Heat Error Based on 1 MW/Degree C in Air (Worst Case)

$$\frac{3.2 \text{ uW}}{.001} = .0032$$

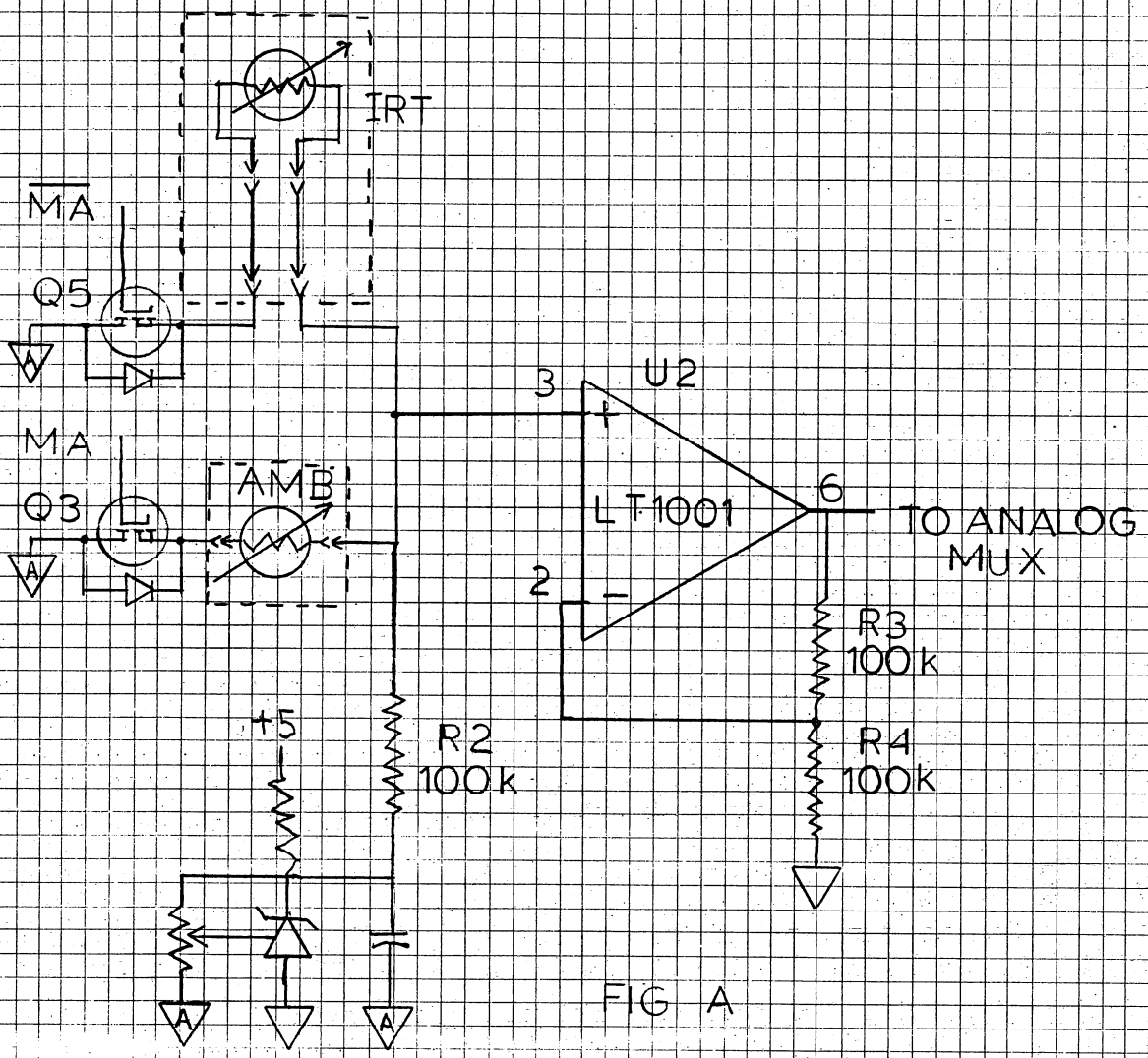

IRT
$\overline{MA}$
Q5
MA
Q3
TAMB
3
U2
2
LT1001
6
TO ANALOG MUX
R3
100k
R4
100k
+5
R2
100k

FIG A

The effect of this change is to make the offset error a much lower statistical component of the signal (improve signal to error voltage ratio.) The following is test data, which is a comparison of a production failure unit to a working sensor PCB. Data is shown for values defore and after the design change.

Sensor PCB 1 MEG Attenuator amp Gain = 16.4

A = Standard Oil "control" sensor PCB
B = MOOG production s/n 243

Sensor	Indcted	Temp	Amplifier Outputs		Amplifier Inputs		Input Difference	
PCB	TRH	TIR	TRH	TIR	TRH	TIR	DCV	%
A	25	25	1.1947	1.1952	.0735	.0735	.0	0
B	25.1	25.5	1.1948	1.1776	.0735	.0719	.0016	2.2

After sensor PCB with attenuator resistor change to 100K amp gain = 2

Sensor	Indcted	Temp	Amplifier Outputs		Amplifier Inputs		Input Difference	
PCB	TRH	TIR	TRH	TIR	TRH	TIR	DCV	%
A	24.9	24.9	1.1560	1.1562	.5769	.5770	.0001	.01
B	24.9	24.9	1.1561	1.1535	.5769	.5754	.0015	.26

This hardware change requires a change in software, specifically some look-up table values.

The look-up table in software changes because of the different amplifier output for various thermistor readings. The look-up table is generated from the following formula:

$$Kt = \frac{Gain * Rt * 4000}{10^5 + Rt}$$

Where: Gain = U2 Circuit gain
Rt = Thermistor resistance at selected temperature
Kt = Expected A/D counts at selected temperature

Table 1 shows A to D count values for various temperature readings.

Conclusions:

The resistor changes in the U2 amplifier will accomplish the following:

1. Allow sensor board to more accurately read thermistors
2. Allow Scheduler to take temperature data down to $0^{o}C$
3. Reduce noise on the output of the amplifier
4. Significantly reduce effects of high humidity error due to increased leakage

OBS	TEMP	IMP	RESIST	COUNT
1	0	94.980	94980	3897.02
2	1	90.410	90410	3798.54
3	2	86.090	86090	3701.00
4	3	81.990	81990	3604.15
5	4	78.110	78110	3508.39
6	5	74.440	74440	3413.90
7	6	70.960	70960	3320.54
8	7	67.660	67660	3228.44
9	8	64.530	64530	3137.66
10	9	61.560	61560	3048.28
11	10	58.750	58750	2960.63
12	11	56.070	56070	2874.09
13	12	53.540	53540	2789.63
14	13	51.130	51130	2706.54
15	14	48.840	48840	2625.10
16	15	46.670	46670	2545.58
17	16	44.600	44600	2467.50
18	17	42.640	42640	2391.48
19	18	40.770	40770	2316.97
20	19	38.990	38990	2244.19
21	20	37.300	37300	2173.34
22	21	35.700	35700	2104.64
23	22	34.170	34170	2037.42
24	23	32.710	32710	1971.82
25	24	31.320	31320	1908.01
26	25	30.000	30000	1846.15
27	26	28.740	28740	1785.93
28	27	27.540	27540	1727.46
29	28	26.400	26400	1670.89
30	29	25.310	25310	1615.83
31	30	24.270	24270	1562.40
32	31	23.260	23260	1509.65
33	32	22.330	22330	1460.31
34	33	21.430	21430	1411.84
35	34	20.570	20570	1364.85
36	35	19.740	19740	1318.86
37	36	18.960	18960	1275.05
38	37	18.210	18210	1232.38
39	38	17.490	17490	1190.91
40	39	16.800	16800	1150.68
41	40	16.150	16150	1112.35
42	41	15.520	15520	1074.79
43	42	14.920	14920	1038.64
44	43	14.350	14350	1003.94
45	44	13.800	13800	970.12
46	45	13.280	13280	937.85
47	46	12.770	12770	905.91
48	47	12.290	12290	875.59
49	48	11.830	11830	846.28
50	49	11.390	11390	818.03
51	50	10.970	10970	790.84
52	51	10.570	10570	764.76
53	52	10.180	10180	739.15
54	53	9.807	9807	714.49

TABLE 1

OBS	TEMP	IMP	RESIST	COUNT
55	54	9.450	9450	690.726
56	55	9.109	9109	667.883
57	56	8.781	8781	645.775
58	57	8.467	8467	624.485
59	58	8.166	8166	603.961
60	59	7.876	7876	584.078
61	60	7.599	7599	564.987

Further Recommendations:

1. Carefully test leakage of mosfets Q3 and Q5 as per data sheet specifications
2. Test resistance of amplifier input runs to adjacent runs on all raw P.C. boards to insure good P.C. process and materials
3. Update MOOG test work sheet #A91575 REVA Section 3.4.3, 3.4.4 and 3.4.6 to show a tighter tolerance to test closer to Scheduler specifications < +/- .36°F. Update section 3.42 to adjust pot for 1.1568 +/- .5 mV
4. Review tester hardware. All sensor lines should be kept as short as possible, use shielded lines and insure tester power supply is not adding noise to Scheduler power supplies

```
200 REM PROGRAM TO CALCULTE THE SPOT SIZE OF AN INFRARED THERMOMETER
210 PRINT "INPUT S, FOR SIMPLE GEOMETRY, C FOR COMPLEX"
220 INPUT GM$
230 IF GM$='S' GOTO 500
231 PRINT
232 PRINT
235 PRINT "COMPLEX GEOMETRY"
240 PRINT "ENTER INSTRUMENT HEIGHT ABOVE CANOPY"
241 INPUT H
255 PRINT "ENTER HORIZONTAL DISTANCE FROM INSTRUMENT TO VIEWED SURFACE"
256 INPUT D
257 REM THE UNITS OF H AND D MUST BE THE SAME
260 PRINT "ENTER INSTRUMENT FIELD OF VIEW IN DEGREES"
261 INPUT T1
262 T1=T1*(PI/180)
270 T1=T1/2
275 X=SQR(D^2+H^2)
280 C=ATN(H/D)
285 G=PI/2-T1-C
290 S=SIN(T1)*X/(SIN(G+PI/2))
295 K=(PI/2)-G-2*T1
296 D=SIN(K)
297 IF SIN(K) < .001 THEN D=.001
300 L=SIN(T1)*X/D
305 T=L+S
310 REM ALL TRIGONOMETRIC FUNCTIONS ARE CALCULATED IN RADIANS
315 W=2*X*TAN(T1)

320 REM PI=3.1415927
360 A=PI*T*W/4
380 PRINT
390 PRINT
391 REM CONVERT ANGLES FROM RADIANS TO DEGREES
392 G=G*57.295
393 C=C*57.295
394 K=K*57.295
400 PRINT "AREA=";A
410 PRINT "total length of spot= ";T
420 PRINT "width of spot= ";W
421 PRINT "short length of spot=";S
422 PRINT "long  length of spot=";L
423 PRINT "K=";K;
426 PRINT "G=";G;" C=";C
427 IF K < 1 THEN PRINT "SOME SKY SEEN"
428 IF K < -1 THEN PRINT "DO NOT USE AT THIS ANGLE"
430 GOTO 230
500 PRINT
600 PRINT
601 PRINT "SIMPLE GEOMETRY"
602 PRINT
605 PRINT "INPUT DISTANCE TO TARGET"
610 INPUT H
620 PRINT "INPUT INSTRUMENT FIELD OF VIEW IN DEGREES"
630 INPUT F
640 F1=F*(PI/180)/2
650 S=2*H*TAN(F1)
660 PRINT "THE DIAMETER OF THE SPOT IS =";S
670 GOTO 230
700 END
```

```
200 REM PROGRAM TO CALCULTE THE SPOT SIZE OF AN INFRARED THERMOMETER
210 PRINT "INPUT S, FOR SIMPLE GEOMETRY, C FOR COMPLEX"
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262 T1=T1*(PI/180)
270 T1=T1/2
275 X=SQR(D^2+H^2)
280 C=ATN(H/D)
285 G=PI/2-T1-C
290 S=SIN(T1)*X/(SIN(G+PI/2))
295 K=(PI/2)-G-2*T1
296 D=SIN(K)
297 IF SIN(K) < .001 THEN D=.001
300 L=SIN(T1)*X/D
305 T=L+S
310 REM ALL TRIGONOMETRIC FUNCTIONS ARE CALCULATED IN RADIANS
315 W=2*X*TAN(T1)

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400 PRINT "AREA=";A
410 PRINT "total length of spot= ";T
420 PRINT "width of spot= ";W
421 PRINT "short length of spot=";S
422 PRINT "long  length of spot=";L
425 PRINT "K=";K;
426 PRINT "G=";G;" C=";C
427 IF K < 0 THEN PRINT "SOME SKY SEEN"
428 IF K < -1 THEN PRINT "DO NOT USE AT THIS ANGLE"
430 GOTO 230
500 PRINT
600 PRINT
601 PRINT "SIMPLE GEOMETRY"
602 PRINT
605 PRINT "INPUT DISTANCE TO TARGET"
610 INPUT H
620 PRINT "INPUT INSTRUMENT FIELD OF VIEW IN DEGREES"
630 INPUT F
640 F1=F*(PI/180)/2
650 S=2*H*TAN(F1)
660 PRINT "THE DIAMETER OF THE SPOT IS =";S
670 GOTO 230
700 END
```